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Mr. C. J. Cox (at right, above) supervises the installation of Okonite Splicing Tape on 2300 volt motor lead in Seabrook Farms food freezing plant. For 29 years Mr. Cox has standardized on Okonite splicing materials to assure water-tight seals on cables throughout the plant. Note moisture conditions indicated by frozen condensation on pump head.

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West Coast Adv. Office
635 S. Kenmore Ave.
Suite 201
Los Angeles 5, Calif.
Tel: DUnkirk 5-3991

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Advertising Production Manager

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M. S. COOVER, President — N. S. HIBSHMAN, Secretary

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For an expansion program of such importance, it is only natural that the greatest possible care is used to make sure that service continuity is maintained and system equipment is protected.

Aerial view of the Hialeah section of Miami—one of the areas where rapid building of homes and industry has increased demand for light and power to six times what it was ten years ago. Hialeah Park is nationally famous . . . open the year around . . . host to hundreds of thousands annually.

Management Development in the Communications Field

GLEN IRELAND
FELLOW AIEE

The importance of providing sound management training programs in industry cannot be overemphasized. Efforts made in this field by The Pacific Telephone and Telegraph Company are outlined.

THE SUCCESS of any management development program depends, to a large degree, upon the people to be developed. Although it is somewhat in vogue to speak of management development as if it were a new and mysterious thing, the fact is that management development has been with us in some form ever since we have had managers, supervisors, or bosses. The early manager or boss frequently was appointed on short notice, shown a new desk, and probably given a brief introduction to his people. Then he was supposed to go to work and start producing.

I was first put in charge of a group of engineers nearly 30 years ago. Although I knew something about the technical side of the work, I did not know how to handle people very well—how to understand their needs and desires, how to talk with them, how to correct their work habits.

In those days, the development of the new manager resulted primarily from only two factors: first, the effort of the individual to improve himself by observation and study—in other words, self-development; and second, what he learned from his boss—now known as the man–boss relationship. Outside of the universities there was little literature on this subject. The newly appointed boss or manager usually had to find out by trial and error and by experience.

This situation has gradually improved over the years. Experience in the period of tremendous industrial expansion of recent years has gone a long way in proving the inability of the older trial-and-error method to produce competent managers in the larger numbers required. In addition, the technological, social, and economic changes that have taken place in the country have all resulted in greater pressures on business managers. It has been said that business has found it necessary to "run faster just to stand still."

The Pacific Telephone and Telegraph Company (PT&T), like other businesses, has been affected by these changes. There has been a rapid evolution in our company, particularly since World War II, toward a more conscious effort to help in the development of the individual at various stages of his career. There will be no attempt here to describe the process of evolution by which we have reached where we are today, other than to say it has been just that —an evolutionary process. We have gained by experience; we have dropped that which seemed least effective and followed along those lines that seemed most fruitful. We have benefited considerably from the advice of the American Telephone and Telegraph Company staff, the experience of other Bell System companies, and the help of outside consultants.

Revised text of a conference paper presented at the AIEE Summer and Pacific General Meeting, San Francisco, Calif., June 25–29, 1956, at a session sponsored by the AIEE Committee on Management.

Glen Ireland is with The Pacific Telephone and Telegraph Company, San Francisco, Calif.

BELL SYSTEM SURVEYS

IN LATER YEARS, we have tried to obtain the ideas of the supervisors themselves at various levels as to what assistance they needed at various stages of their management career. For example, in 1951, and again in 1952, Pacific Telephone, along with a number of other Bell System companies, conducted attitude surveys among the first, second, third, and fourth levels of management people. The questions to be answered in these surveys covered many aspects of the business and, in addition, permitted ample opportunity for its management people to express their views by means of write-in comments. An analysis of these comments (in which anonymity was preserved) indicated that the first-level people felt they needed more training assistance on appointment to management.

To determine just what was needed, seven companies in the Bell System went out and interviewed a number of first-line supervisors and also some of their bosses. The results of these interviews, which were made available to Pacific Telephone, indicated the areas where the supervisors seemed to have difficulties and were least comfortable—where they needed help. Subsequently, by interviewing a cross section of newly appointed supervisors, PT&T determined that the results of the seven-company study were applicable to its situation. It was felt that the approach of obtaining an expression of opinion gave a much sounder basis upon which to build a development course that would really fit the needs of first-line management personnel.

A somewhat similar approach—that is, the use of attitude surveys, write-in comments, and/or individual depth interviews—has been followed in ascertaining the needs and desires of the higher levels of management. As in previous studies, PT&T also obtained the ideas of their bosses. After that, development programs to cover these needs were designed.

MANAGEMENT DEVELOPMENT PROGRAMS

THE SEVERAL management development programs currently being used at Pacific Telephone for the several levels of management are as follows:

Human Relations Training. One of the fundamental skills

which management personnel need is that of working with people so they will know how to make a plant or office the warm, human kind of a place where a person is glad to go every day; so they will know how to develop teamwork and participation; and so they will know how to be "good bosses." Thus, by 1949, Pacific Telephone was well on its way in human relations training.

Participants in this seven-day course presently study and discuss such subjects as the cause–result approach to behavior, individual differences in ability and personality, motivation, frustration, attitudes, the individual and the group, and interviewing. In addition, the participants bring actual incidents to the conference where they have problems in these areas and by discussion work out solutions. This training has been given to all levels in the organization and now is given to all newly appointed supervisors.

Management Induction Training. The attitude surveys referred to previously indicated that first-line people thought they should receive more training on appointment to management. In particular they wanted to know more about their company and how it was organized; something about its history and origin; where they fit into the scheme of things; what authority they had. They wanted to know how best to deal with their people and how to handle grievances. They particularly needed help in talking with their people and in leading group meetings—in other words, how to communicate effectively under various conditions.

The transition from nonmanagement to management status is an important period in an individual's career. There is probably no other time when he is more receptive and eager to learn. Because of this fact, an interdepartmental two-week course for all newly appointed management people, both line and staff, was organized in 1954. The principal items covered are the management job, organization and function, self-development, development of people, talking with people, leading group meetings, and labor relations.

Trainees are organized in groups of 12 on an interdepartmental basis. Study and reading material is provided. A small library is maintained in each conference room, and participants are encouraged to read the books. Evening reading assignments are part of the curriculum. Here again an attempt is being made to motivate first-level management personnel to practice self-development. In the group meetings proper, which are held under the auspices of specially selected and trained group leaders, lecturing and telling are minimized and emphasis is placed on doing. The conferees actually practice talking with people and, more importantly, learn how to listen. They also practice leading group meetings. (Incidentally, the fundamental skills of talking with people and leading group meetings have been found to be so helpful that training in them is being extended to many other supervisors at the first, second, and even third level who have not had the opportunity to obtain this training on induction to management.) Free and open discussion is the rule. The conferees are from all departments, including engineering. Because of the interdepartmental composition of the conference, which includes both first-line men and women, the conferee receives the opportunity to hear and understand the other fellow's problems. One engineer claimed that by the time he got through the course, he could even understand "commercial" people, and vice versa.

Over 3,000 newly appointed supervisors have received this training to date. Extensive sampling of the opinions of supervisors receiving this training has shown that they were warm in their praise and thought it would greatly improve their confidence and performance on the job, particularly when working with people.

Pacific Telephone, like most large companies having a highly complex technical type of business, employs many college graduates each year. In order to orient them properly and introduce them to the business, they participate in a well-rounded training program involving experience in several different departments. As part of their program, these college men have a special two-week training course, similar in many respects to the management induction training.

Pacific Telephone Executive Conference. Further up the management ladder, we have recently organized an interarea interdepartmental conference covering district and division level people (third and fourth levels of management), which are key jobs in the organization.

The objectives of this training are somewhat broader than in the case of the lower levels and may be outlined as follows: (1) To increase effectiveness on the job; (2) To stimulate further self-improvement; and (3) To broaden thinking beyond departmental lines.

There are some 950 men at these levels, including both line and staff, in our organization, spread over four areas on the Pacific Coast and representing a number of functional departments. It was decided, for the start at least, to have one centralized school for Pacific Telephone. This school is located at Palo Alto, Calif., near San Francisco.

Training is being given to groups of 48 persons. Each group comprises a mixture of personnel from different areas and departments. The interchange of views and the friendships formed between persons of different areas and departments are proving to be valuable by-products of the course. The individuals are completely relieved of their regular responsibilities and then attend the course for one week.

The subject of the conferences has been "Handling Changes." This subject was chosen because it could well be that the capacity of a business to adjust to technological, social, political, and economic changes—sometimes radical in nature—will determine whether it moves ahead toward prosperity or falls behind. This, in turn, depends upon the ability of the managers in the business to recognize resistance to change and to deal with it effectively.

In these conferences, the case discussion method was used. The cases themselves were drawn in large part from actual experiences in various Bell System companies where problems have arisen in connection with changes in organization, changes in practices, and changes in assignment of work. Usually, the group is broken down into subgroups for freer discussion. The conferees freely discuss these cases and state what they believe would be the best method of approach and the best solution. In so doing and by having

their ideas challenged by conferees with different viewpoints and experiences, they learn how to listen to the other fellow, how to integrate their own knowledge and experience, and how best to explain them in a coherent fashion to others. Thus, they learn how best to gain acceptance of changes in the telephone business.

In order to broaden their thinking, these conferees are likewise given considerable outside reading material. I refer to such items as Peter Drucker's "America's Next Twenty Years" appearing in the March, April, May, and June 1955 issues of *Harper's Magazine*, and David Sarnoff's "The Fabulous Future," which appeared in *Fortune*, January 1955.

In an effort to appraise the value of this course, a questionnaire was submitted to the participants immediately upon return to their jobs to obtain their reaction to the course and its value to them. Some of the results of this questionnaire are summarized in Table I. From this table it will be observed that the conferees valued the course quite highly. It is planned to submit a similar questionnaire to these people after about six months on the job to see if their feelings remain the same or have changed. Engineers did well in these courses and seemed to gain a lot from the broadening influence.

After all district and division level people have had the course on "Handling Changes," which is near completion, it is planned to cover them in groups again with material on other subjects, such as "Handling Barriers to Communications" and "Planning, Organizing and Controlling the Job."

Bell System Executive Conference. Training at the department head level (fifth level) is aimed primarily at broadening the individual, getting him to think beyond departmental lines and company lines and to project his thinking and plane of reference to one involving business and society as a whole. Nowadays, no business can exist in isolation. Therefore, it is important that our higher level people understand their society and Government in order to become an intelligent part of both.

Here again, the case discussion method is frequently used, but there is more tendency toward lectures. Lecturers and moderators from both inside and outside the telephone business provide different backgrounds and points of view. Subject matter ranges from telephone cases led by telephone men to eminent outside speakers lecturing on "Monetary and Credit Systems of the United States" and "The Economics and Politics of the Federal Budget."

Under a "dean" from the American Telephone and Telegraph Company, men at this level from all over the Bell System have been brought together for this course at a centralized school at Asbury Park, N. J., starting in the fall of 1953.[1] Groups of 40 to 50 have attended the four-week sessions. By next spring practically all of the some 55 fifth-level men in Pacific Telephone will have attended this basic course. And, in addition, some of these will have returned for a two-week refresher course.

College Courses. Colleges and universities offer a wide range of general courses for management education and training. Such courses offer our management people added opportunities to develop and to obtain fresh viewpoints from these institutions and from the men of other companies and businesses with whom they are associated. Pacific Telephone has been sending some 10 to 12 people drawn from the third, fourth, or fifth level to such courses each year.

No mention of college or university courses would be complete without referring to the activity being carried on by the Bell System companies through the co-operation of the University of Pennsylvania. This is the Institute of Humanistic Studies which was started in that university in 1953 at the suggestion of the president of the Bell Telephone Company of Pennsylvania. Each fall some 24 men from various Bell System companies gather for 10 months of continuous study. Pacific Telephone has been sending two men each year. The expectation behind this experiment was that 10 months of concentrated study in liberal arts would broaden the viewpoint and enhance the stature and executive potential of promising young executives. Anyone wishing to know more about this course may refer to previously published articles.[2,3]

Miscellaneous. Pacific Telephone at various times also gives several specialized nontechnical courses to selected members of its management team. These include courses on "Fundamentals of Teaching," "Conference Leadership," and "Labor Relations." The courses are aimed at fulfilling certain specialized needs, as implied by their titles.

AN APPRAISAL

I HAVE ATTEMPTED to outline a program of management training and development which has evolved and is now being used for various levels of management in The Pacific Telephone and Telegraph Company. It is believed that PT&T has made great progress in arriving at a co-ordinated program—one which matches the subject matter of the

Table I. Sample Reactions to Questionnaire on Pacific Telephone Executive Conference

Selected Questions and Choices of Responses	Percentage of Replies
1. Now that the conference is ended, how successful do you feel it was?	
Very successful	81.5
Quite successful	18.3
Fairly successful	0.1
Not at all successful	..
No answer	0.1
2. Obviously this kind of conference is costly. How do you feel about its value to you when related to what it cost the company?	
Definitely worth what it cost	80.7
Probably worth what it cost	19.0
Doubt that it is worth what it cost	0.2
Seriously question that it is worth what it cost	..
No answer	0.1
3. Do you feel this conference will contribute to a broader gauge, competent management in the future or that there will be little residue when the conference is ended (just something interesting or nice to do)?	
Quite sure it will contribute to better management	81.5
Fairly sure it will contribute to better management	17.2
Doubt that it will contribute to better management	0.5
Feel quite sure it will not contribute to better management	..
No answer	0.8
4. Considering how the job back home is run, and the pressures on you to get things done, how much effect do you think this conference will have on the way you run your job?	
Quite a bit of effect	85.4
Some effect but not much	13.6
Little if any effect	0.5
No answer	0.5

individual courses to the varying needs of the several levels of management.

Throughout this program, you will note, there run the threads of several fundamental ideas. Over and above formal training, the most important factors contributing to the development of the individual are his ability, motivation, and willingness to improve himself, and the growth that takes place as a result of the day-to-day relationship with his boss. In formal training the greatest success may be expected when the training is designed to fill the specific needs of the people who are to receive it. This calls for continued studies in which our management people can identify for us the types of problem situations that seem to cause most of their difficulties. Starting with the first level, we have found the importance of human relations—how to deal with people in a warm manner and how to communicate with them effectively through the talking and listening process so as to promote understanding and good attitudes. At the higher levels are those things that will broaden the viewpoint of the individual, increase his potential and stature as an executive and as a man, and enable him to make wise decisions which will best serve both community and company interests.

In the final analysis the extent to which a company goes into these sorts of programs must necessarily be based on experience and judgment. There are some signposts that help to guide the way. Pacific Telephone can obtain the views of outside consultants and can assess its position in relation to that of other companies and businesses with similar problems. In addition, it can obtain the opinions of the men who have gone through such training and, perhaps more realistically, the opinions of their bosses. All of these things have been done and more are going to be done, especially by way of obtaining more opinions from individuals, and from their bosses, at various intervals after the men have completed these courses.

Speaking in a qualitative vein—as a personnel vice president who has had the opportunity to follow the progress of a number of these men for several years after going through such courses—it seems that I find a greater ability to deal with people, including both co-ordinates and subordinates; greater poise and confidence in self; and a greater ability to grasp quickly and deal effectively with new and different situations beyond the usual ken of these individuals. It is my personal opinion that what PT&T has done to date is yielding dividends that will be paying off for years to come.

A LOOK AT THE FUTURE

I BELIEVE that through further study and experience we are going to do a continually better job on management development and, considering the increasing tempo and complexity of modern business, such training will be increasingly necessary. In this connection I look forward to increasing training in the skills of communications, including talking with people and dealing with groups.

No look at the future would be complete without reference to the increasing amount of work that is being done in research in the field of social science. Almost invariably one of the major problems being studied is that of communications.

There are many specific questions, the answers to which would make a real contribution to better management development. For example, I would hope that future research will cast further light on the personal growth of individuals. Think how helpful it would be to have answers to these questions: "Why do some people stop working on their growth; and at such different ages?" and "Why do some people tend to operate within the limits of certain assumptions without ever challenging them—thus limiting their growth?" Other questions in the possible field of research have to do with problems of leadership: "How does a manager get the best balance between the effort of groups and individuals when there is the opportunity for one to achieve at the expense of the other?" and "How can a manager find the best balance between system and uncertainty, or between conformity and nonconformity?"

Organized research in the social science field has not yet developed to the extent of such research in the field of physical sciences and the results, to date, are less tangible. We can hope, however, that in the future there will be more organized research in the social sciences and that progress in the two fields will go forward hand in hand as they should if we are to obtain the fullest advantages of both.

CONCLUSION

PACIFIC TELEPHONE has been working toward a comprehensive program for the training and development of its management people. But PT&T would not like to leave the impression that it is satisfied with where it stands today. By further experimentation, by probing here and probing there, it is hoped that better solutions will be found and further progress will be made.

And the rewards for progress in this field can be very great. Take two companies in the same field of operation. Both recruit their potential managers from about the same sources and in the same way. One company goes on to great success. The other has indifferent success. Why? The fundamental answer may well lie in the development by one company of greater skills and stature in its managers. This makes clear the challenge before us to find the ways and means of developing and training people to meet the increasing complexities of the modern business world.

As a result of over 20 years on the engineering side and over 10 years on the management and personnel side of the business, I believe that personnel work requires the same processes of orderly thinking, of marshaling and analysis of facts, and of inventiveness, as engineers are accustomed to applying in their day-to-day work. I would like to see more engineers enter the personnel field, make contributions to it, and help in meeting the challenge.

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Design of a 4,600-Cps Alternator

J. D. McCRUMM
MEMBER AIEE

TO PROVIDE EXCITATION for a magnetic amplifier operating at a 400-cps signal carrier frequency, a single-phase generator of at least 10 times carrier frequency was needed. This digest describes the design and test performance of a machine rated at 240 volts, 6 amperes at unity power factor, 4,600 cps, 158 poles, 3,500 rpm.

Basic design considerations lead first to the selection of the number of poles and the rotor diameter. The high frequency necessitates high speed, the upper limit being 3,600 rpm for practical reasons. With 158 poles, multiples of 400 cps are avoided at induction-motor drives slips from zero to 7.2 per cent. Mechanical and electrical aspects of stator slot and tooth geometry determine the machine diameter at the air gap, 11 inches being a minimum feasible value. A diameter less than this leads to additional armature inductors because of lower rotor peripheral speed, deep slots, and narrow teeth, all undesirable.

The large number of poles precludes a rotor structure of the usual salient pole type, with individual field coils on each pole. A Lundell-type rotor, shown in Fig. 1, avoids these complications. It consists of two dish-shaped sections of Society of Automotive Engineers *1020* cold-rolled steel with the centers removed. The deep sides of each dish piece have 79 wide slots milled radially. The remaining 79 protruding teeth constitute a set of poles of one

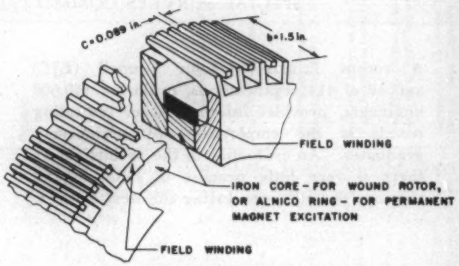

Fig. 1. Lundell-type rotor structure.

Table of Results

	Design	Test
No-load voltage	280 volts	292 volts
Field excitation, rated load, 1.0 power factor	300–400 ampere turns	770 ampere turns
Armature leakage reactance	17.8 ohms	19.3 ohms
Armature reaction (direct axis, per pair of poles, referred to field)	56.7 ampere turns	74.2 ampere turns
Armature reaction voltage	53 volts	62 volts
Effective armature resistance	1.87 ohms	2.11 ohms
No-load running losses	500 watts (estimated)	

polarity, the other section comprising the other set of poles. The sections are assembled with the poles interleaved. The magnetic path is completed through a soft-iron ring between the two sections, and excitation is provided by a single coil wound over and concentric with the iron ring or core. Alternatively, the iron ring may be replaced by a ring of Alnico VI for permanent-magnet excitation.

The armature is wound with No. 29-gauge 3.25-per-cent silicon steel. The air gap is 0.02 inch, the teeth are 0.101 inch wide, and the slots are 0.118 inch wide by 0.282 inch deep. They were designed to hold eight inductors made of No. 18-gauge heavy Formvar wire with 7-mil Mylar insulation. At 6 amperes, the armature current density is 4,700 amperes per square inch, a figure which though high is tolerable. Only six inductors were wound in the actual machine because of the tight space requirements; all inductors are in series. The design was based on a no-load air-gap flux density of 15,000 lines per square inch.

The values of slot leakage reactance and effective armature resistance were computed by classical means, and the predicted and test results are in reasonable agreement. The armature reaction was computed by assuming that the single-phase pulsating magnetomotive force could be resolved into two oppositely rotating components of half magnitude each. Further, because of pole leakage, the field-winding ampere turns necessary to overcome a given armature reaction magnetomotive force at the air gap is some 40 per cent greater than the actual armature reaction magnetomotive force. This increase, together with an arbitrary increase to account for the effect of the negatively rotating half-component gives a predicted value of armature reaction referred to the field, which is 23 per cent lower than the experimental value obtained from the Potier triangle.

The accompanying table lists values of pertinent parameters, both from computation and test.

Investigation was made of possible mechanical failure from excessive vibration of the pole pieces caused by mechanical resonance, centrifugal force on the pole pieces, and the hoop stress of the permanent-magnet Alnico ring. There is adequate safety margin in each case.

The usual tests of open circuit, short circuit, zero power factor, and a load run were made. The predicted saturation curve is markedly different from the actual one, thus explaining the wide difference between design and test results for excitation and armature reaction.

Digest of paper **56-519**, "Characteristics and Design of 4,600-Cps Alternator," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Great Lakes District Meeting, Fort Wayne, Ind., April 16–18, 1956. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1956.

J. D. McCrumm is with Swarthmore College, and consultant to The Franklin Institute, Philadelphia, Pa.

Demand for Engineering Graduates in 1956

SPECIAL SURVEYS COMMITTEE OF ENGINEERS JOINT COUNCIL

A recent Engineers Joint Council (EJC) survey of 414 organizations, exploring 140,000 engineers, provides information for indicating trends in the employment of engineering graduates. An evaluation of the results shows there is very little promise of relief in the shortage of engineers during the next 4 years.

THIS REPORT PRESENTS the summary and evaluation of a survey conducted by the Special Surveys Committee of Engineers Joint Council (EJC) with the staff assistance of the Engineering Manpower Commission (EMC). The survey was conducted during December of 1955 and January and February of 1956 and is based on replies to questionnaires from 414 industrial and governmental organizations. The 414 organizations, which comprise the sample on which this study is based, employ about 140,000 engineering graduates or about 25 per cent of the estimated engineering graduates in the United States.

SUMMARY AND CONCLUSIONS

ONE OF THE MOST VALUABLE RESULTS of the EJC demand studies has been their usefulness in indicating trends in the employment of engineering graduates. Table I presents the information from 1952 through the present year in summary form to indicate the over-all rough trend.

Although direct numerical comparisons are not suggested (since the survey samples are not strictly comparable), a comparison of trends is certainly admissible. During 1952, the demand for engineering graduates expressed in terms of percentage of net accessions (the total of all new hires minus all losses) was 6.4 per cent of the engineers employed at the beginning of the year. On the same basis, the demand declined somewhat in 1953 and dropped off further in 1954. This trend was reversed sharply in 1955 with a higher demand for engineering graduates than was encountered in the previous peak year of 1952, and this trend continued at a much more accelerated pace through 1956. The percentage of net accessions in 1956 in terms of expected acquisitions is 10.1 per cent—the highest ever. In terms of required acquisitions, it is 14.3 per cent.

Table I. Trend of Demand for Engineering Graduates

	Previous Surveys by EJC			Current Survey		
	1952	1953	1954	1955	1956	1956
1. Number of Organizations Reporting	376	376	377	414	414	414
2. Total Engineering Graduates Employed on January 1	117,586	125,086	124,329	132,140	140,446	140,446
3. Total Net Accessions, Calendar Year	7,500	6,692	5,254*	8,306	14,162†	20,125‡
4. Total Engineering Graduates Employed on December 31	125,086	131,778	129,583	140,446	154,608	160,571
5. Net Accessions (Per Cent of Engineers Employed on January 1)	6.4	5.3	4.2	6.3	10.1	14.3

* Projected. † Expected. ‡ Required.

THE REPORTING SAMPLE

THE 414 ORGANIZATIONS which supplied usable data for this survey include 363 industrial firms and 51 governmental agencies. The industrial activities employed 111,272 engineers and the government organizations employed 29,174 engineers in federal, state, and local agencies. As is indicated by the organization of the various tables of this report, returns were classified in accordance with the Standard Industrial Classification (SIC) Code. Those industrial classifications for which the survey provided a reasonably satisfactory sample are classified separately. Those for which the individual samples were insufficient have been classified under the general heading of "Other Industries." The SIC Code numbers of the industries, so summarized, are listed in the tables.

In this connection, it is important to realize that, in some cases, the SIC Code is inaccurate because of the increasing tendency of companies to be active in more than one industrial classification. Inasmuch as the information is obtained generally, it can only be com-

Table II. Total Number of Graduates Required

	1955	1956	
	Actual	Expected	Required
1. Number in Organization on January 1	132,140	140,446	140,446
2. Total Losses During Year (All Causes, Including Military)	11,945	10,828	10,828
3. Employment During Year:			
A. From Current Classes:			
1. Bachelor	8,086	11,343	14,524
2. Master	747	1,119	1,429
3. Doctor	384	600	964
Total	9,217	13,062	16,917
B. From Earlier Classes	9,133	9,561	11,669
4. Number Returning from Military Leave	1,901	2,367	2,367
5. Total Net Accessions (3 plus 4 minus 2)	8,306	14,162	20,125
6. Number in Organization on December 31	140,446	154,608	160,571

Table III. Breakdown by Industry of Actual Engineering Employment, 1955

Industry	SIC Code	Number of Returns	Total Engineers in Employ, January 1, 1955	Employment 1955												
				Total Losses, All Classes	Bachelors	Masters	Doctors	Total	From Earlier Classes	Returns from Military Leave	Total Net Accessions	Total Engineering Graduates in Employ, December 31, 1955	Bachelors Hires, as Per Cent of Total Engineers Employed	Bachelors, Masters, Doctors Hires, as Per Cent of Total Engineers Employed	Experienced Engineers Hires, as Per Cent of Total Engineers Employed
Total of Industry and Government		414	132,140	11,945	8,086	747	384	9,217	9,133	1,901	8,306	140,446	6.1	7.0	6.9
Total Industry		363	103,599	8,395	6,493	689	380	7,562	7,238	1,268	7,673	111,272	6.3	7.3	7.1
Chemicals and Allied Products	28	28	14,165	933	821	108	37	966	485	78	596	14,761	5.8	6.8	3.4
Machinery (except Electrical)	35	40	4,419	619	233	19	5	257	274	9	−79	4,340	5.2	5.8	6.2
Electrical Machinery Equipment and Supplies	36	44	32,127	2,471	2,356	166	213	2,735	2,427	809	3,500	35,627	7.4	8.5	7.6
Transportation Equipment	37	22	10,380	1,099	759	89	23	871	1,668	54	1,494	11,874	7.3	8.4	16.1
Professional and Scientific Instruments	38	12	3,260	265	247	25	5	277	335	21	368	3,628	7.6	8.5	10.3
Public Utilities, Operating Telephone Companies, and Railroads	40, 48, 49	62	16,365	793	499	13		512	358	139	216	16,581	3.0	3.1	2.2
Miscellaneous Services: Consulting Firms, Research and Development	89	75	10,941	1,233	773	151	67	991	1,325	40	1,123	12,064	7.1	9.1	12.1
Products of Petroleum and Coal	29	15	6,685	580	486	84	24	594	133	84	231	6,916	7.3	9.0	2.0
Other Industries	10, 11, 13, 14, 15, 19, 20, 22, 24, 26, 30, 31, 32, 33, 34, 52	65	5,257	402	319	34	6	359	233	34	224	5,481	6.0	6.8	4.4
Government	90	51	28,541	3,550	1,593	58	4	1,655	1,895	633	633	29,174	5.6	5.8	6.6

piled under that code classification which seems most indicative of the over-all activities of any given company.

Because of the difficulty of defining engineering positions and of the fact that individuals sought from outside an organization for work, requiring engineering skill and knowledge, are largely graduates, the Special Surveys Committee of EJC has decided that the most practicable basis for measuring demand is more the need for engineer graduates than for individuals to fill engineering positions.

On this same basis, the responding organizations had been asked to indicate their total employment, of the need for engineering graduates, regardless of expected assignment, recognizing that some may enter upon training for other than strictly engineering work.

The total population from which the survey sample is drawn, therefore, is the number of engineering graduates in the country, excluding those who are retired. This 1955 number has been estimated as approximately 560,000 from data of the Commission on Human Resources and Advanced Training, as of 1953, and brought up to date. This compares with the total of about 675,000 individuals classified as engineers in industry, Government, and other activities, as of the same date, estimated from the 1950 census and from subsequent additions and losses.

The total number of employees in these organizations at the end of 1955 was 3.5 million or about 7 per cent of the total nonagricultural employment of the country and about 11 per cent of the number in the technical fields of mining, manufacturing, transportation, and public utilities, and in Government. The number of engineering graduates in their employ was, as heretofore mentioned, approximately 140,000 of whom 110,000 were industrial companies and 30,000 Government agencies. Because this number is about 25 per cent of the estimated number of such graduates in the country, it is clear that these organizations represent a concentration of such men generally above the average of business, industry, and Government.

The total number of graduates required by these organizations in the categories covered are shown in Table II. The net accession figure represents the final gain (or loss) in engineering graduate manpower.

Further tabular presentation of the data by industry is provided in a table on turnover of engineers in 1955 and the breakdown by industry of the demand figures for 1955 and 1956. The heading "Expected" indicates the number the organizations actually anticipate hiring; "Required," the number they estimate are needed based on firm plans and commitments.

EVALUATION

THE DATA presented in Tables I and II clearly indicate a rise in demand for engineering curriculum graduates in 1955 and 1956, substantially above that in any year since 1951. There is little question, therefore, for now and the immediate future that Government, industrial, and other programs affecting engineering graduates should be oriented to and realistically reflect the deficiency indicated.

It is pertinent to ask for the implications of this 1956 survey data for the over-all national, industrial, and governmental demand for engineering curriculum graduates. A projection of the sample based either on known engineering graduate population or engineering employ-

Table IV. Breakdown by Industry of Expected Engineering Employment, 1956

Industry	SIC Code	Number of Returns	Employment 1956: Total Engineers in Employ, January 1, 1956	Total Losses, All Classes	Bachelors	Masters	Doctors	Total	From Earlier Classes	Returns from Military Leave	Total Net Accessions	Total Engineering Graduates in Employ, December 31, 1956	Bachelors Hires, as Per Cent of Total Engineers Employed	Bachelors, Masters, Doctors Hires, as Per Cent of Total Engineers Employed	Experienced Engineers Hires, as Per Cent of Total Engineers Employed
Total of Industry and Government		414	140,446	10,828	11,343	1,119	600	13,062	9,561	2,367	14,162	154,608	8.1	9.3	6.8
Total Industry		363	111,272	7,660	9,301	1,014	590	10,905	7,694	1,818	12,757	124,029	8.4	9.8	6.9
Chemicals and Allied Products	28	28	14,761	838	910	121	57	1,088	437	121	808	15,569	6.2	7.4	3.0
Machinery (except Electrical)	35	40	4,340	361	555	35	12	602	346	65	652	4,992	12.8	13.9	8.0
Electrical Machinery Equipment and Supplies	36	44	35,627	2,445	3,219	294	324	3,837	2,263	1,016	4,671	40,298	9.0	10.8	6.3
Transportation Equipment	37	22†	11,874	1,150	1,259	166	53	1,478	2,154	113	2,595	14,469	10.6	12.5	18.1
Professional and Scientific Instruments	38	12	3,628	295	377	26	9	412	394	36	547	4,175	10.4	11.4	10.9
Public Utilities, Operating Telephone Companies, and Railroads	40, 48, 49	62	16,581	668	787	13		800	325	157	614	17,195	4.8	4.8	1.9
Miscellaneous Services: Consulting Firms, Research and Development	89	75	12,064	1,070	1,083	214	82	1,379	1,526	120	1,955	14,019	9.0	11.4	12.7
Products of Petroleum and Coal	29	15	6,916	545	649	104	42	795	90	134	474	7,390	9.4	11.5	1.3
Other Industries	10, 11, 13, 14, 15, 19, 20, 22, 24, 26, 30, 31, 32, 33, 34, 52	65	5,481	288	462	41	11	514	159	56	441	5,922	8.4	9.4	2.9
Government	90	51	29,174	3,168	2,042	105	10	2,157	1,867	549	1,405	30,579	7.0	7.4	6.4

Table V. Breakdown by Industry of Required Engineering Employment, 1956

Industry	SIC Code	Number of Returns	Employment 1956: Total Engineers in Employ, January 1, 1956	Total Losses, All Classes	Bachelors	Masters	Doctors	Total	From Earlier Classes	Total Net Accessions	Total Engineering Graduates in Employ, December 31, 1956	Bachelors Hires, as Per Cent of Total Engineers Employed	Bachelors, Masters, Doctors Hires, as Per Cent of Total Engineers Employed
Total of Industry and Government		414	140,446	10,828	14,524	1,429	964	16,917	11,669	20,125	160,571	10.3	11.7
Total Industry		363	111,272	7,660	11,121	1,233	939	13,293	9,419	16,870	128,142	10.0	11.9
Chemicals and Allied Products	28	28	14,761	838	1,116	151	99	1,366	486	1,135	15,896	7.6	9.3
Machinery (except Electrical)	35	40	4,340	361	738	49	17	804	394	902	5,242	17.1	18.7
Electrical Machinery Equipment and Supplies	36	44	35,627	2,445	3,364	346	556	4,266	2,622	5,459	41,086	9.5	11.8
Transportation Equipment	37	22	11,874	1,150	1,772	239	91	2,102	3,059	4,124	15,998	15.0	17.8
Professional and Scientific Instruments	38	12	3,628	295	521	30	10	561	645	947	4,575	14.4	15.5
Public Utilities, Operating Telephone Companies, and Railroads	40, 48, 49	62	16,581	668	1,188	16		1,204	476	1,169	17,750	7.2	7.3
Miscellaneous Services: Consulting Firms, Research and Development	89	75	12,064	1,070	1,212	235	100	1,547	1,477	2,074	14,138	10.1	12.8
Products of Petroleum and Coal	29	15	6,916	545	704	126	51	881	89	559	7,475	10.2	12.8
Other Industries	10, 11, 13, 14, 15, 19, 20, 22, 24, 26, 30, 31, 32, 33, 34, 52	65	5,481	288	506	41	15	562	171	501	5,982	9.3	10.8
Government	90	51	29,174	3,168	3,403	196	25	3,624	2,250	3,255	32,429	11.7	12.1

ment in industry and Government in the United States would unquestionably be misleading, because of the presumption that the needs of the sample represented here are relatively greater than the economy as a whole. In addition, any over-all statistical requirement can be related only to a specific point in time and can be affected rapidly by a whole series of factors acting either independently or in concert. For example, there is little indication here that engineering demand is accumulative over the years. Quite obviously, organizations have learned somehow to perform satisfactorily with under-complements of engineering personnel. Nevertheless, considering all factors, the data would seem to warrant the assertion that the situation would be considerably eased if the total number of engineering graduates this year were of an order of magnitude between 35,000 and 40,000.

It should be emphasized that this situation does not necessarily have implications for the intermediate future. Looking ahead to the next 3 years when the size of the graduating class in engineering will average about 35,000 per year, it is pertinent to note that this increase in the size of graduating classes, combined with a somewhat reduced technological momentum, may have the effect of easing the present situation of extreme shortage. On the other hand, given continuing technological activity with a growth factor similar to that of the recent past, there is little to promise merely numerical relief during the next 4 years.

Table VI. Turnover of Engineers, 1955

Industry	SIC Code	Number of Returns	Total Engineers in Employ, January 1, 1955	Total Losses, All Classes	Losses, as Per Cent of Total Engineers in Employ, January 1, 1955	Total Net Accessions	Net Accessions as Per Cent of Total Engineers in Employ, January 1, 1955
Total of Industry and Government		414	132,140	11,945	9.0	8,306	6.3
Total Industry		363	103,599	8,395	8.1	7,673	7.3
Chemicals and Allied Products	28	28	14,165	933	6.6	596	4.2
Machinery (except Electrical)	35	40	4,419	619	14.0	−79	−1.8
Electrical Machinery Equipment and Supplies	36	44	32,127	2,471	7.7	3,500	10.9
Transportation Equipment	37	22	10,380	1,099	10.6	1,494	14.4
Professional and Scientific Instruments	38	12	3,260	265	8.1	368	11.3
Public Utilities, Operating Telephone Companies, and Railroads	40, 48, 49	62	16,365	793	4.9	216	1.3
Miscellaneous Services: Consulting Firms, Research and Development	89	75	10,941	1,233	11.3	1,123	10.3
Products of Petroleum and Coal	29	15	6,685	580	8.7	231	3.5
Other Industries	10, 11, 13, 14, 15, 19, 20, 22, 24, 26, 30, 31, 32, 33, 34, 52	65	5,257	402	7.6	224	4.3
Government	90	51	28,541	3,550	12.5	633	2.2

ENGINEERING TECHNICIANS

In combination with the survey of engineering graduate demand, a survey of the demand for engineering technicians was conducted. The summary is presented in Table VII. It should be noted that the number of replies and the engineering graduate force of this table are not the same, as shown in the engineering demand tables, because many of the organizations failed to provide information on their technician force. The term technician was intended to include those employed, who were in technical positions by virtue of education in technical institutes (after high school graduation) or by on-the-job training.

It is apparent that industry is coming to recognize the importance of the technician in the over-all engineering manpower situation. The ratio of technician to engineer varies considerably among the various industries and averages 0.73 for the reporting segments of industry and Government. However, in terms of new hires for 1956, the ratio is found to be over 1.00, which leads to the conclusion that demand for technicians is roughly comparable to the demand for engineering graduates. Among organizations employing engineers, those indicating strongest demand for graduates in 1956 are the same which indicate demand for engineering technicians. (Under classification 48 — Telecommunications — the data differs from the average, for reasons of their peculiar well-known high demand for technicians.) This indicates that these companies are seeking to place technicians in as many positions as they are capable of fulfilling, thereby releasing engineers for positions more in keeping with their abilities or, in other words, seeking partial relief to the shortage of engineering knowhow by better utilization of the talents of the engineers.

Table VII. Breakdown by Industry of Employment and Demand of Engineering Technicians

Industry	SIC Code	Number of Returns	Total Engineers Employed	Technicians Employed	Ratio of Technicians to Engineers	Technicians to Be Hired, 1956	New Hires, Per Cent of Total Employed
Total of Industry and Government		356	93,823	68,521	0.73	16,689	24.4
Total Industry		315	73,575	53,825	0.73	13,864	25.8
Chemicals and Allied Products	28	16	1,422	314	0.20	26	8.3
Machinery (except Electrical)	35	35	3,316	2,182	0.66	499	22.8
Electrical Machinery Equipment and Supplies	36	40	23,818	21,950	0.92	4,879	22.2
Transportation Equipment	37	19	6,533	2,803	0.43	911	32.5
Professional and Scientific Instruments	38	11	3,466	1,546	0.45	140	9.1
Railroads, Telecommunications	40, 48	23	8,453	11,857	1.41	5,148	43.5
Utility and Sanitary Services	49	31	6,485	2,372	0.37	298	12.5
Miscellaneous Services: Consulting Firms, Research and Development	89	68	10,301	5,256	0.51	1,466	28.9
Products of Petroleum and Coal	29	13	5,577	1,381	0.25	166	12.0
Fabricated Metal Products	34	13	973	3,099	3.18	216	7.0
Other Industries	10, 11, 14, 20, 22, 24, 26, 30, 32, 33	46	3,231	1,065	0.38	115	10.8
Government	90	41	20,248	14,696	0.87	2,825	19.2

A Slow-Scan Television System for Closed-Circuit Applications

G. H. FATHAUER R. H. SMITH, JR.

A means of transmitting still television pictures over existing low-cost telephone facilities is described. This slow-scan system, utilizing Vidicon camera pickup tubes, will help make the advantages of closed-circuit television available to increasing numbers of users.

APPROXIMATELY two years ago work was started on a project concerning the possible increase in sensitivity of Vidicon camera pickup tubes and in the possible usefulness of a system in which the scanning rates were reduced considerably below those normally used in television systems. Since the signal in the pickup tube is developed by the scanning-beam discharge of a charge built up on the rear of the photosensitive surface it follows that this charge should increase in proportion to charging time and that, therefore, a considerably smaller amount of light could produce the same signal which is normally obtained at rather high light levels. The possible applications of television systems which could be reduced in speed sufficiently to enable transmission of usual voice-type telephone facilities is obvious and, if such a system can remain useful as a television device, the merits of its development can be many.

An initial approach to the development of such a system was based on utilizing readily available major components, and in this respect the use of the common long-persistence phosphor radar-type cathode-ray tube as a viewing device became an obvious choice and automatically dictated certain limitations on the basic concepts. Particularly, it was felt that with the brightness decay characteristic of this type of tube and the commonly known *P7* phosphor used, the picture frequency should be not less than approximately ten per minute in order to maintain some readable information at the top of the picture when the scanning has reached the bottom of the picture.

The other factors to consider in choice of scanning rates are, of course, picture resolution or detail required and bandwidth of the video amplifiers and transmission facilities. In general, it is found that the Vidicon camera tube is readily capable of high-quality picture information up to 300 lines in a picture width. This amount of resolution is also sufficient to provide good picture crispness and detail equal to or better than the average picture to which the television viewer is accustomed.

A study of the telephone facilities available throughout the country shows that for intracity operation, circuits, as well as equalizing equipment and techniques, are readily available with uniform response up to 8 kc and such circuits are very little more expensive than ordinary unequalized voice circuits. Also available are 15-kc circuits; however, it has been found that these circuits are rarely called for in actual use and, consequently, most operating companies are not prepared to supply this service without considerable amount of preparation and delay. Also, since the same basic circuits are used, the loss at 15 kc is approximately twice that at 8 kc and, consequently, under a given set of noise and/or gain conditions twice the distance could be covered if the 8-kc circuits are accepted.

In view of these facts it was felt desirable to try to design a system around an 8-kc channel. A quick computation shows that allowing 5 per cent blanking and synchronizing time, 300-line resolution would permit about 51 lines per second as a horizontal scanning frequency. This is close to our standard 60-cycle power-line frequency; in order to prevent visible effects of power supply ripple and magnetic fields, it becomes extremely desirable to make 60 cycles the horizontal scanning frequency. This would reduce the horizontal resolution to about 255 lines; however, due to the rolloff characteristic of the 8-kc telephone circuits a good 10 per cent extra bandwidth is effected and the original resolution of 300 lines is usually achieved.

Assuming a standard aspect ratio of 3 units high to 4 units wide and a resolution per unit in the vertical direction equivalent to that in the horizontal direction, one would require 225 lines times the Kell factor, or the apparent resolution due to the effect of the fixed positions of the horizontal scanning lines. This, of course, may also require modification depending upon the type of information being observed. In actual practice it is found that a 5-second frame rate which gives 300 scanning lines (less approximately 3 for retrace in the picture) gives excellent results. Actually, this is made variable so that the picture rate can be made as high as possible without impairing vertical resolution for the type of material being viewed.

PHYSICAL DESCRIPTION

THE EQUIPMENT for a complete system is composed of three units: a camera, camera control, and receiving monitor. The camera control and receiving monitor are identical in outward appearance, with the exception that some of the adjustments on the rear of the equipment are necessarily different. The camera measures 3 by 4 by

Essentially full text of conference paper **CP56-688**, recommended by the AIEE Committee on Television and Aural Broadcasting Systems for presentation at the AIEE Summer and Pacific General Meeting, San Francisco, Calif., June 25–29, 1956.

G. H. Fathauer and **R. H. Smith, Jr.**, are with Thompson Products, Inc., Decatur, Ill.

The authors wish to express their appreciation to C. R. Kraus, whose invaluable assistance made most of the field tests, observations, and improvements possible, and whose suggestions and criticisms aided greatly in efforts to improve this equipment.

$6^1/_2$ inches and weighs about $3^1/_2$ pounds. The camera control and receiving monitor are $8^1/_2$ by 10 by $15^1/_2$ inches and weigh 28 pounds each. The camera is connected to the camera control by means of a cable consisting of an *RG59-U* coaxial cable around which are wrapped the eight additional conductors required to feed the camera.

Two sizes of mask opening are employed with the equipment. One measures 2 by 6 inches and the other is 4 by $5^1/_4$ inches. For subjects with a long narrow aspect ratio, the 2- by 6-inch size is desirable, as the scanning time required for the transmission of a complete picture is one half that required by the 4- by $5^1/_4$-inch opening. There is no other difference between equipments having different mask openings. The controls at the rear are simply adjusted to cause the aspect ratio of the scanned raster to fit the mask opening employed. Inasmuch as it is not contemplated that this change will be made in the field, this adjustment is completed before the equipment leaves the test bench.

Since long-persistence phosphors are employed, the degree to which the persistence of the image on the screen is useful in producing a complete picture depends, to a large degree, on the ambient light falling on the screen. Incident light levels in excess of 15 to 20 foot-candles cause the picture to lose its contrast to a considerable extent. For this reason a hood or light shield is provided for the face of both the camera control and receiving monitor. Types of storage device other than the *P7* and *P19* phosphors are available, and one of these, a dark-trace tube, has been successfully operated in laboratory equipment to produce a permanent picture which can be viewed under direct light and then be erased as desired. The image obtained in this case is deep purple and white, and is capable of better resolution and gray scale than the *P7* or *P19* phosphors.

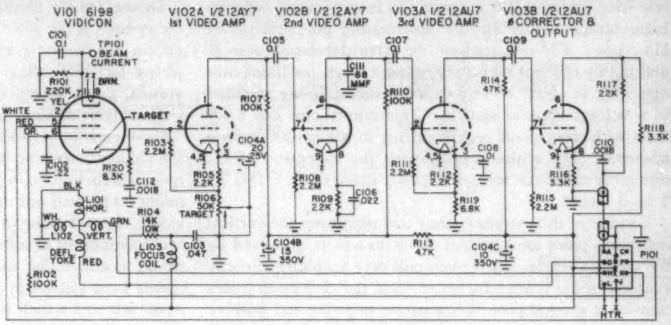

Fig. 1. Slow-scan Vidicon camera.

TECHNICAL DESCRIPTION

THE CIRCUITRY INVOLVED to achieve the necessary functions of this equipment is very similar to conventional closed-circuit television equipment and, except where appreciable differences occur, are described here only briefly. Fig. 1 is a schematic diagram of the camera head itself, which includes the Vidicon pickup tube and the first four stages of the video amplifier. It might be pointed out that the first stage is directly coupled to the Vidicon target in order to keep down stray capacitance and to eliminate a coupling capacitor. Target potential adjustment is obtained by adjusting the cathode resistor in the first video stage. The balance of this video amplifier is a conventional resistance-capacitance-coupled arrangement except for the last stage, which is a phase-correcting stage placed in this particular location because of the better impedance match to the cable running to the camera control unit. The purpose of this phase correction is to compensate for the phase distortion introduced by the partial bypass of the cathode resistor in the second stage and in the first stage of the camera control unit. The combination of these partial bypasses and the phase-corrector stage are for aperture correction, which is the compensation for scanning loss at fine picture detail resulting from the finite spot of the scanning beam in the camera tube.

The partial bypass of the cathode resistors in the third video stage is used to compensate for the input capacity of the first stage and its attendant loss in high-frequency response. One additional compensating circuit is used here, i. e., the combination of the series resistor and capacitor from the Vidicon target to ground which is chosen to compensate for low-frequency phase shift in the system. This phase shift occurs particularly in the line driving transformer in the camera control unit.

Fig. 2 shows the video portion of the camera control including the previously mentioned components. It should be pointed out here that a driven clamp is used at the grid of the final video stage and that direct coupling is employed from that point to the kinescope cathode. It can be seen that without accurate line-by-line d-c restoration a system utilizing these low scanning rates would call for a low frequency response sufficient to pass a 1/12-cps square wave which is, of course, impractical without a completely direct coupled system. The use of the driven clamp reduced this requirement to a low-frequency limit necessary only to pass a 60-cps square wave.

The system power supply which is incorporated in the camera control unit is a conventional electronically regulated supply and need not be discussed here. Also, the horizontal sweep which operates at 60 cps is the same as is used for a vertical-sweep circuit in the conventional television receiver. It should be pointed out here that the deflection coils in the camera control monitor are connected in series with those in the camera head so that the same deflection system operates both the kinescope and the camera pickup tube in direct synchronization.

Since there are no high-voltage retrace pulses such as those which occur in the horizontal scanning of conventional

television systems, it is necessary to incorporate a separate high-voltage supply for the accelerating potential in the kinescope. For this purpose we have developed a small and highly efficient r-f supply, using a single oscillator tube operating at about 80 kc and using subminiature rectifiers in a voltage doubler system. This supply puts out 8,000 volts with very good regulation up to about 200 microamperes. The entire supply, with the exception of the miniature oscillator tube, occupies a space of only $1^1/_8$ by 3 by 3 inches.

Because of the extremely slow scanning rate, the vertical deflection poses some special problems which are solved by the use of a single-ended push-pull type amplifier directly coupled to the yoke. In order that the deflection yokes may be at ground potential, separate negative and positive plate supplies are provided for the bottom and top half of the amplifier, respectively. This circuit is shown in detail in Fig. 3. The drive for the deflection amplifier is obtained from a multivibrator and a resistance-capacitance charge and discharge circuit.

For operation of a remote monitor or receiver, horizontal scanning is synchronized by the same method that is used in simplified industrial television systems; i.e., by merely carrying the horizontal blanking somewhat blacker than black, and clipping this portion off at the receiving end in the conventional sync separator. For purposes of vertical synchronization the usual procedure in simplified industrial television is again to use a blacker-than-black blanking pulse, this pulse being several lines wide. This method was used originally in the slow-scan equipment; however, it requires that the low-frequency transmission of the system be capable of transmitting a pulse of much greater width than is required for video and can lead to difficulties in synchronization, particularly where transformers or repeating coils are incorporated in the system.

In order to overcome this requirement, it was decided to incorporate a high-frequency burst signal during vertical retrace and, thereby, eliminate completely any extra low-frequency requirements. In this equipment the burst operates at 2,000 cycles and is generated by a simple single-tube Colpitts circuit which is keyed on by a positive pulse from the vertical multivibrator during retrace time.

In the remote monitor or receiving equipment the circuitry used is the same as that used in the camera control, except for the sync separation circuits which derive the pulses for controlling the scanning oscillators. For the vertical synchronization, all that is used is a single tuned stage driven directly from the highest level video point. This stage is tuned to the 2,000-cycle burst frequency and the voltage across the tuned circuit is rectified to produce a pulse which, in turn, triggers the vertical multivibrator. It might be pointed out that it is extremely improbable that a video signal having a repetitive large-amplitude 2,000-cycle component of sufficient duration to operate this circuit would occur. The use of the burst-type vertical sync results in a system in which vertical framing is virtually never lost and which is superior to the conventional technique even when complete with RETMA (Radio-Electronic-Television Manufacturers Association) serrated pulses at conventional scanning rates. The sync separation for the horizontal synchronization incorporates a conventional sync separator and amplifier. The sync pulse thus derived is used to drive directly through a transformer, the video clamp, and a driven-clamp type AFC (automatic frequency control) system which controls the horizontal multivibrator type oscillator. Here again a special problem occurs as compared to conventional scanning rates since any imperfect sync, even though at a 60-cycle rate, results in line-tearing rather than frame displacement, and is considerably more objectionable. The use of the driven-clamp AFC system makes horizontal sync virtually immune to random noise pulses and to occasionally missed sync pulses that may occur from noise cancellation or momentary interruptions, and produces a very stable received picture.

TRANSMISSION REQUIREMENTS

The requirements placed on the transmission facility by the equipment can be stated rather readily in terms of three transmission characteristics: bandwidth, phase delay, and midband attenuation.

The upper frequency at which it is desired to maintain uniform frequency response is determined by the maximum resolution desired at the particular scanning frequencies involved. For this equipment, as was indicated earlier, with its horizontal rate of 60 cycles, a 255-line picture will require uniform frequency response to at least 8 kc. In practice, as was pointed out, the nominal 8-kc circuits regularly in use actually provide response beyond 8 kc with resulting resolution improvement.

At the lower end of the frequency spectrum, the transmission system should be capable of passing a 60-cycle square wave. This requirement means that the sine-wave low-frequency response should extend considerably lower

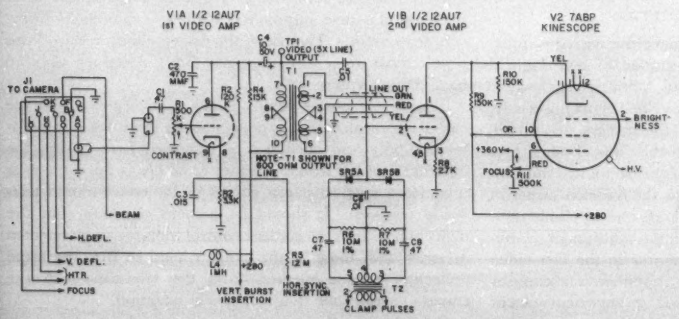

Fig. 2. Slow-scan video amplifier, in camera control unit.

than 60 cycles, with the consequent result that as few repeating coils as possible should be included in the transmission system. Since the output and input circuits of the camera control and receiving monitor already contain line-matching transformers, it is unnecessary to use additional transformers to obtain line balance.

Phase delay, a subject which has been thoroughly investigated at standard television video frequencies, has not been quantified for this equipment. The same general considerations apply, however, and it may be said that where no nonlinear components are present the same techniques which restore uniform frequency response also effect phase correction. No difficulties have been observed due to nonlinear phase delay at the higher frequencies.

At the low-frequency end of the transmission band, nonlinear phase-delay correction is usually not supplied by the telephone facility, as it is not needed in short-distance program transmission. In field test of this equipment, the effect of low-frequency phase distortion (streaking) was observed in a few instances, and preliminary investigations indicate the need for further study of this aspect of slow-scan television transmission.

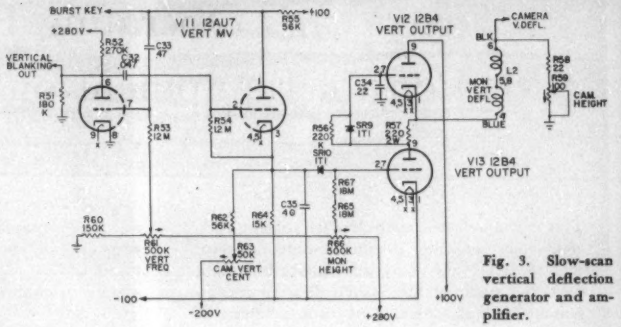

Fig. 3. Slow-scan vertical deflection generator and amplifier.

The receiver has enough reserve gain to compensate for a loss of 20 db in the transmission facility. Therefore, the attenuation of the line at 1,000 cycles, measured after equalization, should not exceed 20 db.

CONCLUSION

IT IS BELIEVED that this equipment represents a practical approach to many of the problems connected with closed-circuit television, because it provides a means of transmitting still television pictures over already-existing low-cost telephone facilities, thus making the advantages of closed-circuit television available to increasing numbers of users.

Underground Freezer Warehouse Constructed in Kansas

In a 9-acre underground cave carved out of solid limestone, a unique installation of General Electric Company rigid steel conduit is used in the first underground freezer of its kind in the United States.

At the Inland Cold Storage Company's freezer warehouse at Kansas City, Kan., built to facilitate interstate movement of frozen foods from the West Coast to the eastern markets, GE White conduit carries the cables from the substation located above ground down through 70 feet of solid stone into the ceiling of the worked-out section of the former quarry and thence to the distribution load center, which is shown at the left of the picture.

In all, approximately $9\frac{1}{2}$ miles of conduit are used for the electrical distribution system which supplies power for refrigeration equipment for more than 300,000 square feet of storage space and for the lighting and other electric equipment.

The storage area in this warehouse can handle 2,500 carloads of frozen food. Refrigeration keeps 275,000 square feet of the area at a constant temperature of −5 F. Another 50,000 square feet is kept at 32 F.

Serving the freezer warehouse is a railroad spur capable of bringing 18 cars at one time to the loading platforms which are located underground. In addition, a truck dock, at the entrance to the plant, is designed to handle 15 trucks simultaneously.

The GE White conduit installation is subjected to several extreme conditions. It must withstand alkalis and acids in the soil and rock as it bends down into the former quarry. It must also resist moisture and humidity in the storage and refrigeration areas. In many places, the conduit is constantly covered with ice.

First Year's Operating Experience with Control Equipment on Subway Cars

G. W. WEBER
ASSOCIATE MEMBER AIEE

This new all-electric controller for subway cars, completely replacing pneumatic-type contactor and reverser, has many advantages including decreased maintenance, standardization of components, simplification, and reduced weight. Major problems encountered in building and operating sample equipment in 100 New York City Transit System subway cars, are discussed.

MULTIPLE-UNIT ELECTRIC TRAIN operation in the present-day high-speed rapid-transit service demands an extremely high degree of equipment reliability. This performance must be achieved with a minimum of time and labor for maintenance. Efforts to achieve these objectives have, in recent years, produced notable advances in the design of both propulsion and control equipment.

The type of car currently being placed in service in large quantities by the New York City Transit Authority is equipped with four 100-hp motors. This amount of power requires a control with a resistance switching mechanism capable of handling 250 kw and providing smooth accelerating and dynamic braking characteristics. This mechanism must be able to operate through a cycle of approximately 30 steps as many as 500,000 times per year. In addition to meeting these requirements, it must have low inspection and maintenance costs.

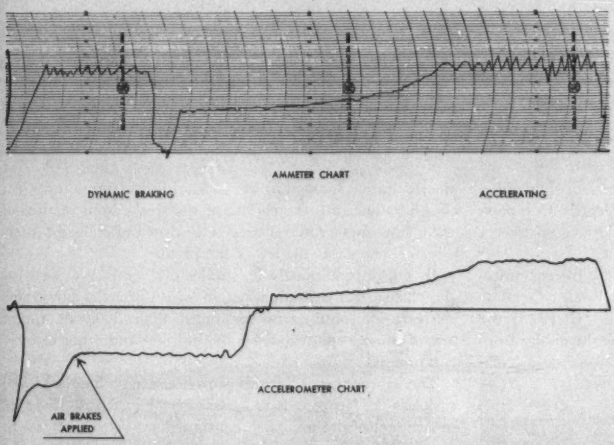

Fig. 1. Performance charts of rapid-transit car equipped with type MCM control.

ALL-ELECTRIC CONTROL

EARLIER APPLICATIONS used banks of pneumatic contactors to perform this function, but these had the disadvantages of too few steps and high maintenance costs. In 1947, a pilot-motor-driven cam-operated resistance-stepping controller was developed to fill these requirements. This radically new discrete notching controller provided simultaneously sufficient notches to reduce acceleration impulses below the "passenger feel" threshold and low maintenance because of its ideal contact closing action.

The new controller was first sold on 375 subway cars for New York City. Its success in this application naturally led to the proposal that a second controller be added on future cars to assume the other major functions of power switching. This would completely replace the pneumatic contactors and reverser, making an all-electric control possible. The elimination of the use of compressed air in the control operation led to the name "MCM" (motor-driven, cam, magnetic) for this control.

The advantages to be derived from this new system offered powerful incentives for its adoption. They included decreased maintenance, standardization of components, simplification, and reduced weight. Yet, the disadvantage of adopting a completely new control system weighed heavily against the proposal. To minimize the initial service problems and to demonstrate the real advantages of MCM control, a sample equipment was built and operated in revenue service from 1952 to 1955 on the New York City Transit System. Here, the fundamental control system problems involved in the remote control of series

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G. W. Weber is with General Electric Company, Erie, Pa.

Fig. 2 (left). Trackside door conveniently located to facilitate making necessary adjustments. Fig. 3 (right). Control equipment mounted underneath a rapid-transit car; covers removed to show accessibility of equipment.

motors to provide fast and smooth response in power and dynamic brake were solved. Device design weaknesses, as well as system malfunctions, were detected and corrected. In a system of this size and complexity, however, the proof of the pudding is not in the tasting but in the full-scale eating of it. Thus, in the manufacture and initial servicing of the first hundred MCM equipments for the New York subway, many problems developed. This article discusses the major problems encountered, the functional performance attained, and the over-all maintenance picture after service operation of these equipments for a year.

DESIGN AND MANUFACTURING PROBLEMS

Factory Test. One of the most serious problems arose early in the manufacture of the equipment, long before the first car was put into service. The motor-driven controllers stopped by dynamic braking on the pilot motor. This is a highly desirable feature since it eliminates the need for friction clutches or mechanical ratchets on the controller. However, this leaves only the inherent friction of the camshaft to resist any tendency of the controller to creep under the influence of vibration and the loading reaction from the cam contours. Conditions of adverse cam loading and low friction were soon found that caused notch skipping on some of the controllers. A sweeping redesign of the cams was made to reduce peak camshaft loading torque in the stop zones of the controller. Since this change, 600 controllers have been built and operated for periods up to one year without a single known case of notch skipping from this cause.

Each control group was given a rigorous functional test by means of special test equipment, designed to reproduce the car circuits and operations. In addition to its primary function of detecting manufacturing defects, this test equipment also proved valuable in detecting design weaknesses. In several instances, control equipments failed to respond positively to test conditions, revealing loop-holes in the controller positioning circuitry, where in-tolerance manufacturing variations could cause system malfunctions. To a large extent these difficulties were eliminated before the first car was track tested.

Track Test. During the track testing of the first 10 cars, operating conditions were found that could cause the new magnetic line breakers to pump under load. The circuit at fault was designed to reduce line breaker coil excitation current and thus minimize load on the control train line wires. A new "optimized" line breaker coil design permitted the elimination of this circuit and of the problem it had caused.

The first cars were processed through track test almost without incident. Control response in both accelerating and dynamic braking proved to be fast and smooth. Typical ammeter and accelerometer charts are shown in Fig. 1. These smooth accelerating and braking characteristics rendered interaction between cars practically nonexistent. Track test adjustments were quickly and easily made by means of the small trackside door, Fig. 2, which gave easy access to equipment for all adjustments. As many as four cars per day could be processed by the same track test crew, if necessary.

Service Experience. To date, 100 cars equipped with this control have been in service on the Brooklyn–Manhattan Division of the New York City Transit Authority for approximately 18 months. An additional 200 cars have been in service on the Interboro Rapid Transit Division for approximately 9 months. These cars are operating an average of 70,000 miles per car per year in extremely severe service.

With 300 equipments on what amounts to a mass life test, even the slightest design weakness or malfunction quickly becomes apparent. For example, shortly after the cars entered revenue service, operators found that the line breakers were tripping occasionally at third-rail gaps. Investigation revealed that a third-rail gap, occurring at a critical point in the acceleration cycle, could cause the controllers to go out of position. During the reapplication

of power after passing the third-rail gap, two traction motor armatures could be connected directly across the line without their fields, resulting in a flashover. Once recognized, the problem was completely eliminated by a simple interlock change.

As would be expected, there have been a number of difficulties of the "growing pain" variety. These have not been more numerous or serious than might be expected when a radically new equipment of such magnitude is placed in so exacting a service. Some, like the case mentioned, have been easily corrected as soon as recognized. Others have required further investigation and occasional changes in details of equipment design or circuitry.

Whenever a trouble has come to light, it has been dealt with in a manner that will preclude further occurrence. While a few difficulties have not been completely cleared up as yet, intensive effort is being devoted to them with good prospects of early correction.

Table I. Unattended Service Life—MCM Equipment

Device	Part	Quantity	Unattended Service Life, Miles
Line breakers	Contacts	4	50,000 (estimated)
	Arc chute	2	100,000
	Arc horns	2	100,000
Controller—main circuit switches	Contacts	4	100,000
Controller—notch interlocks	Contacts	4	100,000
Current limit relay	Contacts	2	100,000 (estimated)
Magnetic contactor	Contacts	2	100,000
Relays	Contacts	10	100,000
All other contacts and wearing parts			over 500,000

MAINTENANCE

Present Picture. Recently an evaluation was made of the maintenance requirements of the MCM control equipment. Each part that is subject to wear or erosion was studied and its "unattended life" evaluated. The results of this analysis are shown in Table I.

A bogey of 100,000 miles has been set for the minimum maintenance period or "unattended life" of every control component. Only the line breaker has fallen short of this to date. At present its minimum is estimated at 50,000 miles. Further improvements in this area are being studied but the extreme duty on these breakers—approximately 10 load interruptions per mile—may make the 100,000-mile goal impractical.

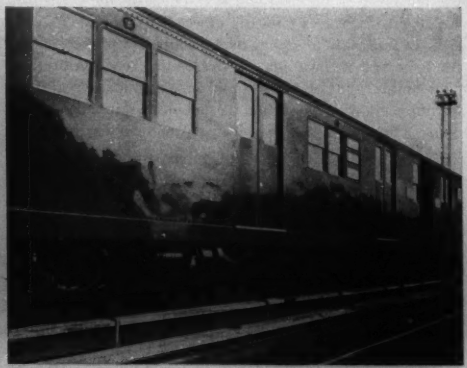
The established inspection period on equipment of previous types was 3,000 miles. As a result of a recent maintenance study, an inspection period of 7,500 miles has been adopted for the new equipment, and a 15,000-mile period is being evaluated. Inspection periods at intervals as high as 30,000 miles may ultimately be found to be practical.

Of particular interest is the "unattended life" of the large number of resistance controller contacts. Because of the nonarcing system design and the ideal contact closing mechanics, these contacts will last well over 500,000 miles. Such contact life is not considered possible in devices that pound on closing or arc on opening; or where partial closure can cause spitting, overheating, or welding. With the discrete notching controller, the camshaft travel is divided into alternate "run" or "switching" zones and "stop" zones, where all contacts are fully closed. The controller cannot hesitate or stop in a "run" zone with contacts partially closed.

Inherent Advantages. The long maintenance-free life of this control is caused in part to the elimination of the internal wearing parts inherent in pneumatic devices. The critical wearing parts of magnetic relays and contactors and of motor-operated controllers are readily accessible for inspection and maintenance (Figs. 3 and 4). Therefore, frequent inspections for the purpose of detecting hidden troubles before they cause failures are unnecessary. The maintenance man can replace visibly worn parts and close up the MCM control with full confidence that no hidden troubles will grow into failures before the next inspection.

The oil can, another big maintenance headache, has been eliminated. This is of particular advantage where the

Fig. 4 (left). View under a car on the inspection pit, showing accessibility of control equipment and convenient working position. Fig. 5 (right). New York City Transit Authority subway car, showing MCM control equipment under floor.



air is heavily laden with brakeshoe dust. Periodic cleaning is made infinitely easier by the absence of oil drippings and splatter. To date, no routine lubrication of the control equipment has been found necessary.

Trouble shooting on this control has been made easy through the use of a small test unit that can be clipped onto the control under the car. With this unit, a sequence test can be made in a few minutes that is so complete that it easily detects 99 per cent of all propulsion control troubles. This test unit has proved invaluable in dealing with initial service problems on the equipment.

FUTURE DEVELOPMENTS

CONTROL EQUIPMENT of the MCM type is readily adaptable to all-electric car operation. This has been demonstrated by the two sample cars now in operation on the lines of the Chicago Transit Authority. These cars utilize dynamic brakes (80 to 2 mph) as the primary brake, eliminating air brake equipment entirely. If this scheme were adopted on large rapid-transit cars of the type used in the New York subway, a major reduction in weight and maintenance costs would be achieved by elimination of the air brake equipment. The principal obstacle at present is the need for a reliable high-capacity electrically-operated brake for holding and emergency duty, and to supplement the dynamic service brake, if necessary.

CONCLUSION

A SURVEY OF THE SERVICE HISTORY of the first 100 MCM control equipments placed in service indicates that they have proved capable of successful performance under the severest kind of operating conditions. Acceleration and braking are very smooth, and control response is fast.

A maintenance study of these same equipments indicates that original objectives are being achieved. There is every indication that added experience will permit further extension in inspection intervals, thus giving fuller realization of the advantages inherent in this type of equipment.

In addition to the 300 equipments presently in service, 125 more are on order and specifications are being prepared for several hundred additional cars.

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"Avalanche" Diode Is Useful in Voltage Regulation

The "avalanche" diode is a special type of diode which exhibits a very sharp reduction in impedance at a certain specific inverse voltage. Devices having this characteristic are useful in voltage regulation or control devices, as voltage reference elements, and in signal circuits, as surge protective elements.

Recently, Bell Telephone Laboratories engineers have developed techniques for making diffused junction silicon "avalanche" diodes having lower impedance and higher power capability. In addition, the breakdown voltage can be controlled over a range of about 5 to 500 volts by controlling the junction impurity gradient, and the breakdown voltage of specific units can be predicted quite closely from a knowledge of this gradient. Lowering the impurity gradient by increasing the depth of penetration increases the breakdown voltage.

Fabrication technique consists of diffusing phosphorus into a p-type silicon wafer to form a p-n rectifying junction. The ohmic junction on the other side of the wafer is formed by diffusing boron into the silicon, then plating with nickel. With this technique, contact resistances as low as 10^{-3} ohms per square cm can be achieved.

In the range of 10 to 100 volts, breakdown voltage can be predicted and controlled in production to within about 5 per cent. Above and below this range, accurate control is more difficult, and units may vary as much as 15 per cent.

Current prior to breakdown is of the order of 1 microampere or less for units rated at 10 volts and above. At breakdown, the impedance is reduced to a few ohms for currents in the milliampere range, and can be on the order of a fraction of an ohm for high-current surges.

Dr. H. S. Veloric of Bell Telephone Laboratories, New York, N. Y., is testing a medium-power "avalanche" diode. This particular unit breaks down at 20 volts and is capable of dissipating 6 watts with an appropriate heat sink. Abruptness of the "avalanche" effect can be seen from the trace on the oscilloscope.

A Time-Dependent Nonlinear Compensating Network

J. C. CLEGG
ASSOCIATE MEMBER AIEE

SINCE ABOUT 1950 there has been a trend toward the use of nonlinear circuit elements in servomechanisms. Previously such elements were avoided because of difficulties in handling nonlinear differential equations. With improved mathematical techniques and widespread use of digital and analogue computers, more use is being made of nonlinear compensating devices. Nonlinear compensators can usually be made to show significant improvement in performance over their linear counterparts but often at the cost of increased complexity and expense.

The network shown in Fig. 1 represents a compromise between circuit simplicity and the ultimate in performance. It is designed primarily to improve transient response. Consider this network to be placed in the error path of a position servomechanism to whose input a positive step function is applied. This causes an initial positive error voltage E (since the servo output cannot respond instantly). The leading edge of the error voltage pulse is transmitted without attenuation through the upper diode and capacitor C_A to point F and from there to the remainder of the servo system where it is amplified and caused to drive an output motor in such a direction that the error begins to diminish.

As time progresses, C_A acquires a charge at a rate determined by the time constant $C_A R_0$ (neglecting the effects of R and R_A) and the step-input magnitude. When the rising voltage across C_A equals the falling error voltage, the diode can no longer conduct. The only remaining path for the error signal is through the sign changer and R to the point F. Previously this branch of the circuit had been ineffective because the impedance of R is high compared to that of the diodes and capacitors, but with neither diode conducting the negative error voltage can appear at F. This negative voltage causes the motor torque to reverse, decelerating the load and ideally bringing it to rest at the zero-error position. The servo would now be unstable (since the negative error voltage tends to drive the load away from the zero error position) if it were not for the fact that C_A discharges through R_A at about the same rate that the error is reduced. Thus, by the time the load has reached the null point, both capacitors are essentially discharged (C_B has never yet received a charge), allowing the diodes to conduct if necessary to override any sign-changer signal.

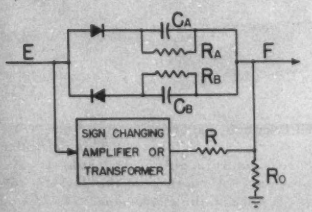


Fig. 1. Compensating network.

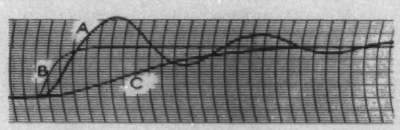


Fig. 2. Output response of servomechanism to step input. A, uncompensated system with normal damping. B, compensated system with increased gain. C, uncompensated system critically damped.

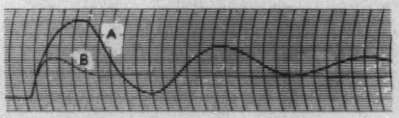


Fig. 3. Servomechanism error for ramp input. A, uncompensated system with normal damping. B, compensated system with increased gain.

If the step input had been negative, the lower diode and C_B, rather than the upper branch of the circuit, would have been active. If the output motion has an overshoot, first one branch and then the other is active.

In many servomechanisms, the error appears as a modulated alternating voltage. The behavior of the network toward such a voltage is essentially as described previously except that both diodes conduct and both capacitors become charged whether or not there is an overshoot in response. Variations in carrier frequency do not affect the response. Use of this network in a-c systems can make it possible to eliminate expensive devices such as tachometers and demodulators or a-c lead networks (such as the parallel T) which require nonstandard components and are sensitive to changes in carrier frequency.

The network requires no adjustment to accommodate different magnitudes of step inputs because the charge acquired by either of the capacitors is proportional to the input. The switching time is determined in part by the capacitor charge and hence is automatically adjusted for different input magnitudes.

Figs. 2 and 3 shows the effect of the network of Fig. 1 on an otherwise linear third-order servomechanism. It can be seen that for two of the most common types of disturbances, step position and step velocity (ramp) inputs, the transient terms are smaller and of shorter duration when the network is used.

Digest of paper 56-778, recommended by the AIEE Committee on Feedback Control Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer and Pacific General Meeting, San Francisco, Calif., June 25–29, 1956. Scheduled for publication in AIEE *Applications and Industry*, 1956.

J. C. Clegg is with the University of Utah, Salt Lake City, Utah.

Ultrasonic Detection of Electric Discharges

J. G. ANDERSON
MEMBER AIEE

AT PRESENT the methods used to detect failures during factory tests of electrical apparatus are of sufficient sensitivity to detect all real faults that occur. However, these methods sometimes do not supply sufficient information for laboratory research and developmental tests of coil stacks and other types of insulation structures. In addition, the present methods have certain other disadvantages such as insensitivity to small corona discharges, sensitivity to high-capacitance charging currents and external circuit sparking, and no positive indication of the discharge location.

To overcome these difficulties, an ultrasonic technique has been developed to detect and locate impulse and low-frequency discharges in insulating structures. This technique can be used during application of almost any type of voltage and does not interfere with normal voltage and current measurements. It has been used with considerable success during dielectric tests of liquid-immersed electrode configurations and coil stacks, and probably could be applied in modified form to tests on solid or gaseous insulations.

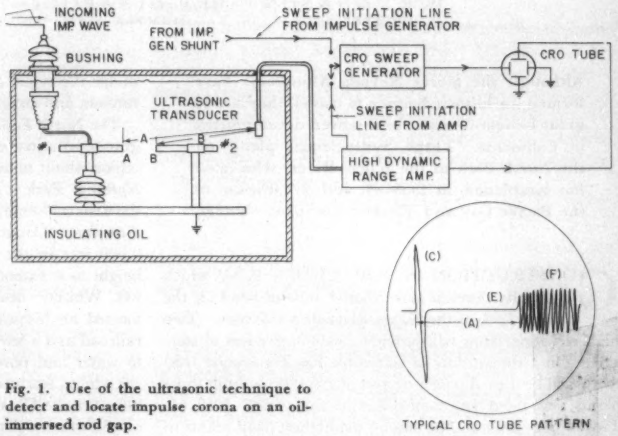


Fig. 1. Use of the ultrasonic technique to detect and locate impulse corona on an oil-immersed rod gap.

This method is based on the observation that an electrical discharge in a dielectric medium produces ultrasonic pressure variations which propagate radially outward through the medium with the velocity of sound. By measuring the time delay required for this ultrasound to travel to one or more suitably located transducers, the location of the discharge can be determined. Because of this finite time delay and the fact that it will be different for transducers at various locations, the interference caused by extraneous circuit sparking, rod-gap noise, and other types of measurement disturbances is considerably reduced.

Fig. 1 shows the ultrasonic method being used to locate corona during impulse tests on an oil-immersed rod gap. At the instant the impulse generator is fired, a cathode-ray tube has its horizontal sweep initiated either from a small surge coming direct from the impulse generator or by electrostatic pickup from a small ultrasonic transducer in the oil. This initiating signal is deflection *C* on the CRO (cathode-ray oscilloscope) tube pattern. The corona ultrasound will arrive after a time delay *A* and appear on the scope as a band of high-frequency oscillations. This time delay indicates the distance to the discharge. For power frequency testing, the CRO sweep can be initiated by the transient current produced by the corona or spark discharge or by the arrival of ultrasound at one of a group of transducers.

The limitations of the ultrasonic method of discharge detection and location are determined by the nature and complexity of the test structure and by the amplitude of the ultrasound produced by the discharge. Deeply embedded discharges may have their ultrasounds severely attenuated, and in complex structures the first appreciable sound may arrive by a devious path or after one or more reflections. A limitation of the ultrasonic detection technique in the testing of completed transformers is the magnetostriction noise produced in the core steel.

Barium titanate has been found to be a satisfactory transducer material for high-voltage tests in liquids, because of its ability to drive long cable lengths. It has been found desirable to use high gain, high dynamic-range amplifiers with a frequency response up to about 300 kc to amplify the signals from the transducers. The high dynamic range was necessary for rapid recovery from transient overloads caused by transient pickup when an impulse generator is fired.

The use of ultrasonic techniques to detect and locate electric discharges in insulating structures is of considerable value, particularly in high-voltage tests of liquid-immersed apparatus where magnetostriction or high ambient noise levels are not present.

Digest of paper 56-744 "Ultrasonic Detection and Location of Electrical Discharges in Insulating Structures," recommended by the AIEE Committees on Transformers and Dielectrics and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer and Pacific General Meeting, San Francisco, Calif., June 25–29, 1956. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1956.

J. G. Anderson is with the General Electric Company, Pittsfield, Mass.

Hydroelectric Development on the North Fork of the Kings River

W. R. JOHNSON
MEMBER AIEE

D. P. DINAPOLI
MEMBER AIEE

J. B. COOKE

Although the Sierra Nevada Mountains have formed an historic barrier to travel, they are of great benefit to water and power developments in California. Three hydroelectric plants on the North Fork of the Kings River, scheduled for completion in 1959–61, add 276,000-kw to the Pacific Gas and Electric Company system.

CONSTRUCTION IS NOW UNDER WAY which will fully develop more than 1 mile of head on the North Fork of the Kings River in California. Two high elevation dams will provide 230,000 acre-feet of storage. On a design flow of 760 cubic feet per second (cfs) there will be a total power output of 296,000 kw from three plants scheduled for completion in the period 1959–61. Two of the plants will be among the highest head plants in the United States.

The project will include the installation of the largest vertical-shaft impulse turbines in the United States, an underground powerhouse, a high head penstock crossing under the river, two high rock fill dams, unlined pressure tunnels, and automatic operation of the chain of plants.

The North Fork of the Kings River originates in the high granite country of the Sierra Nevada Mountains in the region about midway between Mt. Whitney and Yosemite National Park. The Sierras extend for 430 miles along the eastern boundary of California, in a roughly north–south direction. Commencing with crest elevations of 8,000 or 9,000 feet in the north, the range gradually increases in height as it extends southward, culminating in 14,495-foot Mt. Whitney near the southern end. The Sierras have formed an historic barrier to travel, crossed only by one railroad and a few highways, but have been of great benefit to water and power developments in California. During the winter, storms off the Pacific sweep inland over the lesser height of the Coast Range, and deposit heavy precipitation on the western slopes of the higher Sierras. This precipitation, in the form of snowpack, normally is released during the late Spring and early Summer snowmelt period. Some water is held and slowly runs out from small mountain lakes. The natural underground storage is limited because of the massive granitic structure of the mountains with only a thinly scattered mantle of soil supporting moderate to heavy stands of timber below timberline elevations.

As a result of these conditions, the normal pattern of stream flow for rivers originating in the Sierras is a heavy flow during the snowmelt period of late Spring and early Summer, followed by very low flows during the late Sumer, Fall, and most of the Winter. The annual runoff may vary considerably from year to year, some very dry years yielding as little as 60 per cent of the average, and wet years being in excess of the average. Power demand, on the other hand, is greatest in the low runoff

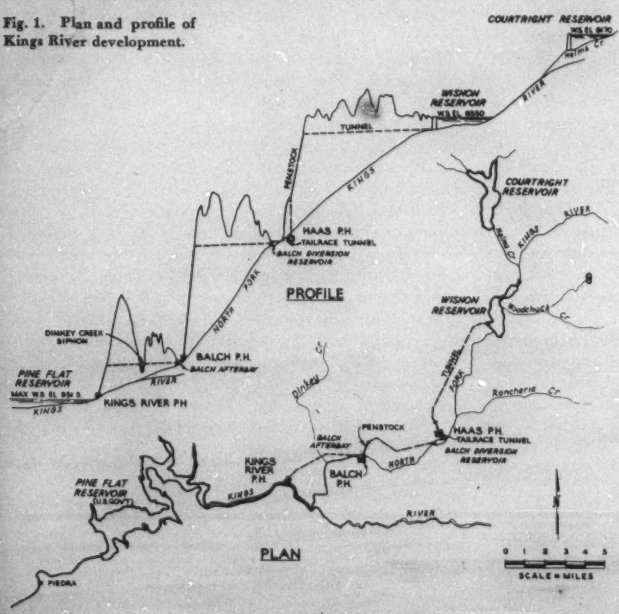


Fig. 1. Plan and profile of Kings River development.

Full text of a conference paper presented at the AIEE Summer and Pacific General Meeting, San Francisco, Calif., June 25–29, 1956, and recommended for publication by the AIEE Committee on Power Generation.

W. R. Johnson, D. P. Dinapoli, and J. B. Cooke are with the Pacific Gas and Electric Company, San Francisco, Calif.

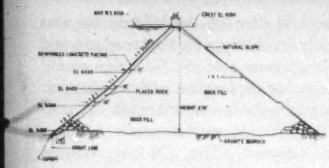
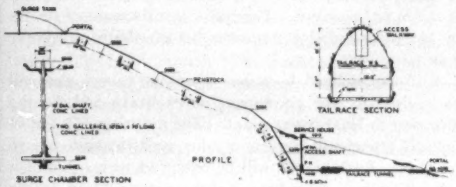


Fig. 2 (left). Section of Wishon Dam. Fig. 3 (below). Profile of Haas project penstock and tailrace tunnel.



months of August, September, and December, and in the dry years.

Because the usual stream-flow characteristics are not suited to power development, high-elevation storage is necessary. High-level storage on the Kings project will be achieved by construction of two reservoirs totaling 230,000 acre-feet storage capacity. This storage will be in excess of the average runoff and will permit cyclic storage for dry years. As a result of this high-level storage coupled with downstream reregulation, the output of the project can be peaking capacity that will be made dependable with suitable capacity factors throughout the year and during dry years. This type of hydro capacity can be most effectively integrated with the large steam capacity on the Pacific Gas and Electric (PG and E) Company system. An additional benefit from the operating flexibility of the project will be to provide system regulating capacity for frequency, tie line, or area load control.

The plan and profile of the development is shown in Fig. 1. Every foot of head will be utilized between Wishon Reservoir water surface and 40 feet below the maximum storage level at Pine Flat. There is inadequate water supply to develop economically the head between Courtright and Wishon Reservoirs.

THE KEY TO THE POWER DEVELOPMENT

THE NORTH FORK of the Kings River has two high-elevation dam and reservoir sites and a very favorable potential power drop. However, all the natural flow is already allocated to irrigation. Major problems are obtaining water to fill the reservoirs and reregulation of power releases to meet irrigation requirements. The solution of these water problems is the key to the power development. This has been provided by the construction of Pine Flat Dam and by agreements and co-operation with the water users and Government agencies.

Power development commenced when the first unit of Balch Power House was placed in service in 1927. This initial Balch unit has been operated with daily regulation between a limited forebay and afterbay to maintain natural stream flow. It was believed at that time that a dam soon would be constructed by private or public agencies, that would provide the necessary reregulation to permit the construction of the power storage reservoirs, additional power plants, and the enlargement of Balch. Twenty-seven years later, such a dam, Pine Flat, was placed in service. The depression and World War II were major factors in the long delay.

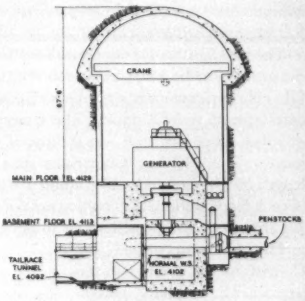
The 1 million acre-foot Pine Flat Reservoir was completed by the U. S. Army Engineers in 1952. This reservoir is a flood-control reservoir, which also provides irrigation benefits and reregulation of the 230,000 acre-feet of power storage. A contract for the reregulation service has been executed by PG and E Company and the United States under the Flood Control Act of 1944. PG and E Company will pay the United States for the reregulation service.

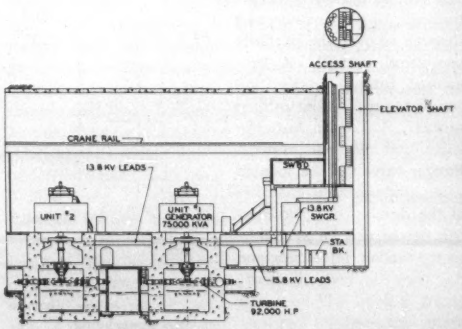
With the knowledge that the necessary reregulation would be possible with the completion of Pine Flat in 1952, PG and E Company applied for Federal Power Commission licenses in 1948. The licenses were issued in 1955 and construction was started in the same year.

STORAGE RESERVOIRS

WATER AND POWER STUDIES indicated 230,000 acre-feet of storage to be required. Only two natural reservoir and dam sites exist in the steep granite country, and economic analysis indicated that the storage should be shared by providing 102,000 acre-feet at Courtright and 128,000 acre-feet at Wishon. Unfortunately, the best reservoir and dam

Fig. 4 (right). Transverse section of Haas powerhouse. Fig. 5 (below). Longitudinal section of Haas powerhouse.





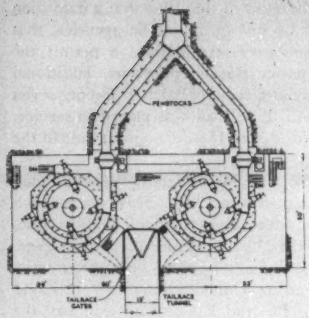


Fig. 6. Sub-basement plan of Haas powerhouse.

site has the smallest drainage area. The drainage area of 39 square miles for Courtright is small compared to 139 square miles for Wishon. However, by assigning all the carry-over storage to Courtright and essentially emptying Wishon each year, the two reservoirs will provide the storage at minimum cost and both reservoirs will begin each summer essentially full.

Both dams will be concrete-face rockfill dams on exposed granite sites. The only available material is granite, except for a nominal supply of river sands and gravel for concrete. Fig. 2 shows a typical section. The design of Courtright and Wishon Dams includes improvements and major economies over previous designs, based largely on the company's experience covering some 60 years and 16 dams of this type. Maintenance on the thin impervious concrete membranes has been negligible in cost.

The two feasible types of dam for the Courtright site were determined to be a concrete arch and a concrete-face rockfill. No impervious material is available for an impervious core-type of rockfill dam. The concrete-face rockfill was adopted, since the arch was estimated to cost substantially more. The 310-foot Courtright dam will have a crest length of 950 feet and will contain 1.45 million cubic yards of rock faced with 22,000 cubic yards of reinforced concrete. An abutment quarry will act as an open crest rock spillway.

The diversion tunnel for Courtright is sized for the permanent outlet works. Flood flows during construction will, to some extent, pass through or over the partially completed rockfill. A submerged intake grizzly will connect to an $8\frac{1}{2}$-foot unlined tunnel. A 72-inch butterfly valve and 48-inch Howell-Bunger valve will be located in an underground chamber at the dam's axis. No electric power will be available, so the hollow jet valves and the two 56-inch butterfly guard valves will be water motor operated.

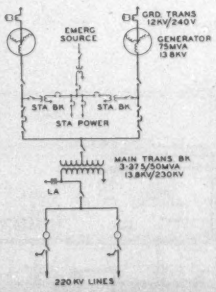


Fig. 7. Single-line diagram of Haas powerhouse.

The concrete-face rockfill dam for the Wishon site was determined to be the only feasible type for the broad exposed granite site. A thin impervious core rockfill design would have cost about the same, but exploration within a distance of 20 miles failed to locate suitable core material. A concrete gravity dam was estimated to cost nearly twice as much as the design adopted. The 270-foot Wishon dam will have a crest length of 3,350 feet and will contain 3.7 million cubic yards of rock, faced with 60,000 cubic yards of reinforced concrete. The spillway will consist of six 40-by $11\frac{1}{2}$-foot radial gates across the left abutment quarry floor.

A 15-foot unlined horseshoe diversion tunnel also will be utilized for the permanent outlet works and for the diversion to Haas power plant. The upstream 500 feet of unlined tunnel will connect a submerged intake to a wye junction. Each branch will be equipped with a 120-inch butterfly valve. One branch of the wye will lead to the permanent outlet valves of the dam. The other branch will be the tunnel to the Haas plant.

HAAS PROJECT

Haas is the upstream and most interesting of the three power projects. Its butterfly-valve intake, 330-foot-head

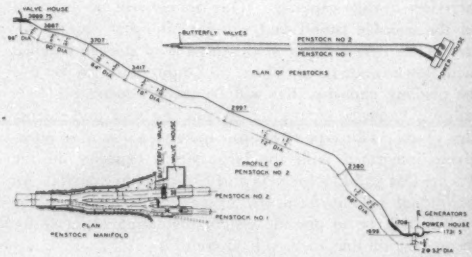


Fig. 8. Profile of Balch project penstock.

unlined pressure tunnel, 350-foot high-surge chamber, 2,444-foot head penstock, underground powerhouse, and the large vertical-shaft impulse units are all unusual.

The Wishon reservoir and Balch forebay were fixed locations. Study of five alternate schemes of developing the head between the two water surfaces resulted in the adopted scheme of the high-head Haas plant. The scheme will develop all the head, is estimated to produce power at the lowest cost, and presented the most engineering problems.

Water Conduits. The plan to develop the head and make available the full storage capacity of Wishon reservoir requires a $6\frac{1}{4}$ mile long, 13-foot horseshoe pressure tunnel with 220 feet of head at the upstream end and 330 feet at the downstream end. Diamond drill holes at low points on the tunnel profile established the feasibility of the high-head unlined tunnel. Where rock conditions permit there are appreciable savings in the use of an unlined tunnel section instead of a concrete lined section.

A 350-foot high combined gallery, simple and differential-type surge chamber, has been designed to provide 1-minute load ON or OFF for any reservoir level in the 220-foot operating range. The adopted design uses a 10-foot diameter by 280-foot long shaft, connecting a load on gallery to a load rejection differential tank. This design takes economic advantage of the fact that rapid and large surges are permissible for such a high-head plant. Two 10- by 75-foot long galleries set just above the tunnel accommodate load on from minimum Wishon reservoir level with minimum surge. A minimum surge is desirable to limit the head on the already high-head tunnel. The surface differential tank accommodates load rejection from maximum Wishon reservoir level. The diameter of tank and the magnitude of surge above maximum reservoir level satisfy the condition that the sum of the surge-tank cost and incremental penstock cost be a minimum.

The profile of the penstock and a section of the tailrace tunnel and surge chamber are shown in Fig. 3. The economic diameter and thickness of a single penstock for 760 cfs and 2,444-foot head at Haas was determined to be 76 and $2^3/_4$ inches, respectively, for American Society for Testing Materials *A212B* Firebox steel. The 4,560-foot long single line will branch to the two units adjacent to the powerhouse. The penstock is a major cost item and the cost of the heavy walled pipe at the lower end was the primary factor in the decision to put Haas powerhouse underground.

Underground Plant. Since World War II, underground schemes have been adopted at an increasing rate all over the world, except in the United States. In the United States, there are located three of the world's first four underground plants, but none of the nearly 100 such plants constructed since that time. The first four underground plants are believed to be: Snoqualmie Falls, Wash. (1898), Fairfax Falls, Vt. (1904), Breckbergmuchle, Germany (1907), and PG and E Company's Spaulding No. 1, Calif. (1913). The 125,000-kw Haas plant will be the first major underground plant in the United States. The powerhouse location study at Haas illustrates that very special conditions are necessary to make an underground design economic in the United States.

Fig. 3 illustrates the underground arrangement. The estimated capitalized saving of this design over the conventional surface design exceeds $1 million. The special conditions at this site that make going underground economic and feasible are: (1) the flat penstock profile at the lower end of a very high-head penstock, and (2) the ideal massive granite formation. The saving is in substituting unlined tailrace tunnel for heavy-walled high-head-loss penstock. The unlined tailrace tunnel will cost about one fourth as much per foot and will have negligible head loss compared to the penstock. The layout adopted will develop 28 feet of additional head. The underground powerhouse itself, even in ideal granite, is estimated to cost more than a surface plant. To move the powerhouse further into the mountain was estimated to be uneconomical, inasmuch as the saving in penstock cost of the steeper and lighter penstock was less than the increased cost of access shaft, penstock shaft, and transformer leads.

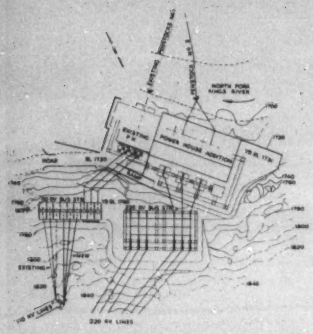
Fig. 9. General view of initial Balch project. Fig. 10 (Insert) Close-up view of initial Balch plant.

The underground powerhouse will be approximately 500 feet vertically below the surface and 2,000 feet from the river. The general arrangement of the powerhouse and equipment is shown in Figs. 4, 5, and 6. The machine hall will be approximately 50 by 173 feet in plan and 105 feet in height. An 18-foot diameter access shaft will lead to the surface and contain generator leads, elevator, stairway, ventilating duct, and control leads. The tailrace tunnel will have an excavated section approximately 15 feet wide by 17.5 feet in height and will contain an access walkway. The tunnel will be paved for use as an access roadway during the powerhouse construction or subsequently, if necessary, for maintenance purposes when the plant is shut down.

Power-Plant Equipment. It is planned to install two 92,000-hp vertical-shaft multinozzle impulse turbines each connected to a 75,000-kva generator unit. The generators will be of conventional design with a thrust bearing that supports the total weight of the rotating parts. The two guide bearings will be capable of carrying the maximum side-thrust load caused by the turbine hydraulic unbalance when operating with any combination of nozzles. Generator cooling water will be pumped from the tailrace.

The generator leads will be connected to metal-clad air-blast switchgear. From the switchgear the low-voltage leads will be extended up the vertical access shaft to a transformer bank and high-voltage switchgear, located above ground nearly directly over the power house. This arrangement is estimated to be more economical than locating the transformers underground. Single-phase transformers will be used because of transport difficulties over the mountain roads and the weight limitations of the bridges. Fig. 7 is a one-line diagram of the plant.

Experience at other installations has confirmed the desirable features of vertical-shaft multinozzle impulse turbines, as compared with horizontal single-nozzle turbines for large high-head plants: (1) Higher efficiency can be obtained throughout the operating range. (2) A greater output per unit enables a saving to be realized by a reduction in the number of units. (3) The turbines may be set



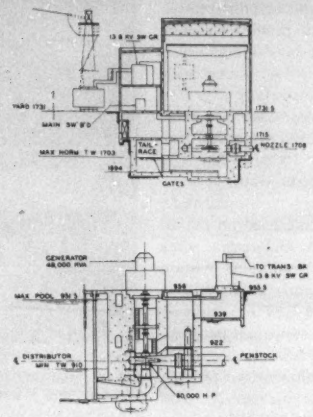


Fig. 11 (top left). Balch powerhouse. Fig. 12. Transverse section (top right) of Balch power house addition, and (right) Kings River powerhouse.

closer to tailwater and thereby permit fuller utilization of head. (4) A higher unit speed is possible which may result in cost savings in the turbine and generator. (5) Effective energy dissipation can be obtained upon load rejection by deflecting the jets into energy absorbers on the wheelpit wall. (6) There is less hazard of damage to the plant in the event of runner or nozzle failure than in the case of a horizontal-shaft machine. (7) The water hammer hazard to the penstock from a single faulty nozzle operation is less for the multinozzle unit, because each nozzle controls a small part of the total flow.

The turbine shut-off valves will be of the spherical type, double seated with the downstream seat acting as the normal shutoff. The operating controls will be arranged to engage the downstream seats upon normal valve closure. However, by engaging the upstream valve seat, maintenance work and adjustments may be performed on the downstream seat without affecting the operation of the other unit. The shut-off valves will be attached directly to the spiral distributor instead of being located in a separate excavation, as is characteristic of many underground stations.

The governor will be an actuator type and will control the needles and jet deflectors. The needles which control the jets will be operated by individual servomotors and the rate of travel for closing and opening can be set to prevent serious penstock pressure rise or drop. The needle servomotors will be provided with external springs to automatically close the needle nozzles in the event of governor system failure. The rates of load pick-up and load-off will both be 1 minute.

In the event of sudden load rejection, the jet deflectors will deflect the power jets in approximately 2 seconds from the runner buckets into the energy absorbers, located in the runner pit. Thus, the speed rise can be held to a low value. There will be a man-door into the runner pit to give complete access for inspection and maintenance of the runner, deflectors, needle points, and nozzles. The runner will be removed by lowering it to the bottom of the runner pit and raising it through a hatchway provided in the tailrace. The removal or replacement can be done without disturbing any other components of the unit or affecting the operation of the other unit.

BALCH PROJECT

Construction in 1927 consisted of the partial completion of concrete arch diversion and afterbay dams; the driving of a 12 by 12-foot $3^2/_3$-mile tunnel, adequate for the ultimate project development; and the installation of the first one-of-four proposed penstocks to supply the first of four 40,000-hp double overhung impulse turbines.

The present enlargement of Balch will include the raising of both of the arch dams, alterations to the surge chamber, construction of a single larger capacity 2,389-foot head penstock, and the installation of two vertical-shaft multinozzle impulse turbines. The changes from three to one penstock, from three to two units, and from horizontal- to vertical-shaft turbines are indicative of the advancment in the art since the initial construction.

There are 66 square miles of snowmelt drainage area between Wishon Dam and Balch Diversion. Raising the existing diversion dam by 44 feet will improve the operating flexibility, permit scheduled peaking with the Spring runoff, and reduce spill caused by diurnal flow variations. The afterbay dam will be raised to prevent loss of head between the Balch and Kings River plants, and the Balch turbine nozzles will be set 4 feet above the spill crest elevation.

In contrast to the Haas plant, the lower portion of the Balch penstock profile is very steep, as shown in Fig. 8, and locating the plant underground is not economical. There is inadequate space for a powerhouse on the penstock side of the river, and both the original development and the new addition are located on the far side of the river, with the penstocks extended under the flow channel and up into the powerhouse. Fig. 9 is a view looking upstream showing the general character of the terrain, existing penstock, power plant, and afterbay dam. Fig. 10 is a view looking down the existing penstock showing the location of the proposed installation to the left of the exsiting plant. The general arrangement of the powerhouse addition and equipment will be as shown by Figs. 11 and 12. It will be noted the tailrace channel is beneath the powerhouse.

The present plan contemplates the installation of two vertical-shaft 67,000-hp multinozzle impulse turbines connected to 54,000-kva generators. The vertical impulse turbines will have the same advantages and features as those for the Haas plant. The vertical unit will have a turbine setting 10-feet lower than the existing plant, while the generator floor level will be higher and afford additional flood protection.

The low-voltage switchgear, transformers, and high-

voltage switchyard are located behind the powerhouse in an arrangement similar to many other plants that are on this system.

KINGS RIVER PROJECT

THE RAISED BALCH AFTERBAY DAM will be the diversion to the Kings River plant through a tunnel and siphon conduit totaling nearly 4 miles in length. A differential surge chamber will be connected near the downstream end of the tunnel, and a single penstock approximately 1,700 feet in length will lead to the powerhouse located near the upstream end of Pine Flat Reservoir.

The outdoor plant installation will include a single 60,000-hp vertical-shaft Francis turbine connected to a 49,000-kva generator. The general layout of the plant, transformers, and switchgear will follow conventional arrangements. The one feature differing from typical plants will be a setting of the turbine well below the maximum possible water surface of Pine Flat Reservoir with an extended shaft to the generator floor above this level, as shown in Fig. 12. A static head of 793 feet will be developed between the normal water surface of Balch afterbay and an overlap of 40 feet on the Pine Flat Reservoir. This upper portion of the reservoir will seldom be filled, and particularly in dry years when dependable capacity of the project is essential the head will be available for the Kings River plant.

TRANSMISSION

TRANSMISSION OUTLETS for the Haas and Balch plants will be at 220 kv, and for the Kings River plant 110 kv. Both the 220-kv and 110-kv lines will be connected to the existing PG and E Company high-voltage transmission system, making the output of the project fully available for system as well as local power requirements. This system includes an integrated transmission network of more than 2,500 miles of 220-kv circuits and 4,000 miles of 110-kv circuits, serving 46 counties in northern and central California.

Because of the extent of the existing system, the transmission for the Kings River development can be provided with a minimum of construction. Outlet from the Haas and Balch plants will be over two 220-kv circuits, $5^1/_2$ miles from Haas to Balch, and 45 miles from Balch to the McCall Substation south of Fresno in the San Joaquin Valley. Single-circuit horizontal-configuration steel-tower construction will be employed in the mountain section. The Valley section will be double-circuit vertical-configuration steel-tower construction. Overhead ground wires will be installed only in the mountain sections adjacent to the powerhouses.

The existing 110-kv tower line to Balch powerhouse will be used to provide transmission for the Kings River plant. This line is a double-circuit steel-tower line built for the original Balch development with only one circuit strung. The second circuit will be installed, and both the Kings River plant and the original Balch plant will be connected to both circuits. This line connects to the system network at Piedra and Sanger Substations east of Fresno in the San Joaquin Valley.

CONTROL AND OPERATION

MANY EXISTING HYDRO PLANTS on the PG and E Company system have been converted to automatic or semi-automatic control, and all recently designed plants have been arranged for automatic operation. This practice has resulted in fewer or no operating attendants being required and has provided greater safeguards to equipment than is normally obtained with manual control.

The Haas, Balch, and Kings River plants will be designed for full automatic operation. However, it is expected that attendants will be maintained at the Haas plant location and the operating center in the Balch plant. Water level, supervisory control, and alarm circuits will be established from Haas to Balch, and from Kings River to Balch. These will be carrier-current channels on the 220-kv and 110-kv transmission lines. Water-level indications from the unattended, as well as inaccessible in winter, storage reservoirs will be transmitted by microwave to Haas.

Each plant will be arranged for automatic start-up under normal conditions with protective features to shut down and lockout in case of serious trouble in the plant. Restart after shut down for lesser trouble will be either automatic or by supervisory control.

Several methods will be used, alternatively or in combination, for controlling the output of each of the plants. At Haas, supervisory control will be used either to set the load at a scheduled fixed level or to delegate control to automatic tie-line or frequency regulating equipment. The Balch and Kings River plants will have the same means of load control as Haas and, in addition, will be provided with forebay water-level load control. When all three plants are used for governing purposes, it will be necessary to proportion the load changes among the three plants in order to maintain operation with maximum heads and no waste of water.

Impulse turbine plants, such as Haas and Balch, are particularly well suited to regulation of system frequency, tie-line control, or other load-control arrangements. Both of these plants, as well as the Kings River plant, will be designed to pick-up or drop-off full load in 1 minute. A high degree of operating flexibility will be possible with the Haas plant supplied directly from Wishon reservoir, and with the intermediate water regulating storage of the Balch forebay and afterbay dams, plus final discharge into Pine Flat.

The 276,000 kw of additional hydro peaking capacity to be produced by the completion of the Kings River development will be effectively integrated with the existing steam and hydro system. This system at present includes 15 steam-electric plants totaling 2,886,300-kw capacity and 58 hydroelectric plants totaling 1,451,500-kw capacity, as well as interconnections with other electric utilities and power-producing agencies. The 1955 peak load on this system was 3,788,700 kw. An average of approximately 300,000 kw of additional capacity per year is required to meet load growth requirements. Other developments now under way include large steam-electric and hydroelectric installations. The power development on the North Fork of the Kings River is an important part of the program to serve the growing needs of the area.

A Phasor Method of Nonlinear Network Analysis

J. P. NEAL
MEMBER AIEE

PHASOR METHODS can be used in the analysis of the steady state of any nonlinear electrical network whose steady-state voltages and currents can be adequately represented by the sum of a limited number of simple sinusoidal functions of time. The method outlined herein can be applied by means of elementary mathematics and, at the same time, provides a grasp of the influence of the individual nonlinear elements on the steady state of the network. The method is explained in terms of impedance concepts but can be applied with equal facility using admittance concepts.

The direct attack used in this method requires some engineering judgment for the determination of the frequencies which are significant in the analysis. However, in practical problems, adequate engineering information is often obtainable from experiment and analyses of the physical system.

Consider a nonlinear electrical network operating in a specific steady state, wherein each of the network voltages and currents can be adequately represented by a finite series of simple sinusoidal functions of time. When such series representations have been substituted into the network voltage equations and the terms simplified by means of trigonometric identities to simple sinusoidal functions, the terms of the same frequency can be separately equated. Each term in each single-frequency voltage equation may be interpreted as the voltage of a linearized harmonic network element. The set of voltage equations of each frequency can thus define a harmonic network for that frequency and of the same plan as the basic nonlinear network.

The phasor method of nonlinear network analysis follows the procedure outlined above. The series representations of the dependent currents have symbolic amplitudes and time angles for the frequencies selected as being significant in the region of operation being investigated.

The selection of the significant harmonics is the crux of this method. It is based on previous experience, experiment, and preliminary analyses. Extremely nonsinusoidal wave forms may often be represented by the sum of a very few harmonic components; consequently, a few significant harmonics is often adequate for practical purposes.

The sets of single-frequency voltage equations can be represented in phasor form, the phasors for each set implying the corresponding frequency. The coefficient parameters of the linearized harmonic elements can be functions of the amplitudes and phase angles of any of the harmonic currents. Therefore, the evaluation of their amplitudes and phase angles requires the simultaneous solution of all the harmonic network voltage equations. This coupling which exists between the harmonic networks leads to multiple solutions for a given set of independent voltages. The uniqueness of a solution can be established only by considering the initial conditions by transient analysis.

Stability Considerations. For any specific phasor-form solution to represent a steady state, it must be stable. Instability may exist because random disturbances will not die with time or will cause a relatively gradual transition to a more stable state.

Instant-Stability Test. The instant-stability test assumes that small random variations of each harmonic current encounter the same instantaneous influence as encountered by that harmonic current in the linearized harmonic network. In other words, each harmonic network is examined for stability as though it is a linear network, each coefficient parameter being held constant at the value obtained for the specific solution concerned.

Average-Stability Test. The average-stability test assumes that after instant stability has been verified, small random variations of the amplitudes and phase angles of the phasor-form dependent currents can be analyzed by the method of variations. On this basis, certain tests were developed which analyze the apparent input impedance facing each harmonic source. These conditions for average-stability at any harmonic source are

$$\left(\frac{\partial(I^2R)}{\partial I}-\frac{\partial(IX)}{\partial\theta}\right)>0$$

$$\left[\frac{\partial(IZ)^2}{\partial I}+2\left(\frac{\partial(IX)}{\partial I}\frac{\partial(IR)}{\partial\theta}-\frac{\partial(IR)}{\partial I}\frac{\partial(IX)}{\partial\theta}\right)\right]>0$$

where $E\epsilon^{j\theta}$ = the harmonic source voltage, $I\epsilon^{j\theta}$ = the harmonic input current, $Z\epsilon^{j\theta}$ = the harmonic input impedance, $Z^2=R^2+X^2$, $P=I^2R$, and $E=IZ$.

When the variations with respect to θ are relatively negligible, the average-stability conditions reduce to

$$\frac{\partial P}{\partial I}>0 \text{ and } \frac{\partial E}{\partial I}>0$$

In this case, average stability is verified at a particular harmonic source when the graphs of P and E vs I have only positive slopes within the region of operation.

This method of analyzing multimesh-multinode nonlinear networks has a number of worthwhile features. The dependent currents of any suitable network can be evaluated to any desired accuracy if sufficient labor is expended.

The amount of labor required should not be overestimated. For repetitious calculations with similar networks the lengthy expansions need not be repeated.

The complete nonlinear influences are divided into component influences which can be successfully analyzed and evaluated. Coupling between the harmonic networks takes the conditions into account which prevented the use of the principle of superposition.

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J. P. Neal is with the University of Illinois, Urbana, Ill.

Electrochemical Aspects of Underground Corrosion and Cathodic Protection

W. E. EDWARDS
MEMBER AIEE

The basic electrochemical principles involved in the corrosion of underground metallic structures are explained. Methods of preventing this costly corrosion process are outlined.

NEARLY ALL underground metallic structures, especially those of iron and steel, require either eventual repair and replacement or continual anti-corrosion maintenance in order to protect them. The vast majority of this work is caused by natural corrosion, or the electrochemical eating away of the metals. A lesser amount of damage is caused by electrolysis resulting from stray underground electrical currents. Why and how this happens, and how it can be prevented electrically, is the subject of this article.

WHY AND HOW UNDERGROUND CORROSION

NATURAL CORROSION seems to lie in the perpetual efforts of Nature to reduce man-made metals back to the natural state from which they came. Metals in the form of ores may remain practically unchanged for untold centuries. Yet most of these ores, when reduced and refined, produce metals which exhibit various degrees of corrosivity, or the tendency to oxidize.

Oxidation occurs through the inherent tendency of metals to ionize whenever they are exposed in various solutions of moist soils. They release positive ions, actual atomic-sized charged particles of metal. These ions have a great affinity for negative oxygen ions; water and oxygen are always required for the formation of rust on iron and steel.

Metals and alloys in an electrolyte also form primary electric cells. Under their influence the charged particles migrate away from the metal and unite with other particles in the solution or soil. In doing so, they cause electric currents both in the metal and in the liquid or soil, and the metal itself gradually passes into solution. Such natural corrosion is referred to as electrogenetic corrosion, or galvanic corrosion. The former is the better technical term.

Certain properties of metals and some related electrochemical terms require discussion and definition before reaching a better understanding of underground corrosion in general.

The common metals are arranged in an electrode-potential series or table for cathodic protection and corrosion study. When this is done, it is most practical to list them with gold at the top or positive end and magnesium at the bottom or negative end. It is customary to show positive values above a reference point or line and negative values below. The table recognizes the natural electric potential difference at the interface between a metal and its own surrounding salt solution of normal ionic concentration. It is the potential on the metal which is of utmost importance to the cathodic protection or electrical corrosion engineer.

The element hydrogen is listed in the table as a convenient voltage electrode reference, or zero point. An electrode is a conductor by means of which an electric current is led into or out of a liquid (or gas). In the case of hydrogen, it becomes an electrode through a solid coating of hydrogen bubbles on a platinum wire. The nonmetallic element carbon is listed in the table because of its common use in cathodic protection and other electrical work. The series is shown in Table I and its use as shown is strongly recommended in all corrosion and cathodic protection work.

Table I. The Electrode-Potential Series

Element Symbol	Common Elements	Potential on the Metal, Volts	Remarks
Au	Gold	+0.98	Cathodic, noble, or electropositive metals or elements with respect to hydrogen
C	Carbon	+0.90	
Pt	Platinum	+0.86	
Ag	Silver	+0.80	
Cu	Copper	+0.35	
H	Hydrogen	0.00	
Pb	Lead	−0.12	Anodic, base, or electronegative metals with respect to hydrogen
Sn	Tin	−0.14	
Ni	Nickel	−0.23	
Fe	Rusty Steel	−0.25	
Fe	Iron	−0.34	
Cd	Cadmium	−0.40	
Fe	Bright Steel	−0.44	
Cr	Chromium	−0.56	
Zn	Zinc	−0.76	
Al	Aluminum	−1.34	
Mg	Magnesium	−1.55	

The tendency of a substance to pass into solution by releasing positive ions results in what is referred to as its solution pressure or solution potential. This is usually measured by the electric potential difference between the metal in a solution or electrolyte containing its own salts and the reference electrode hydrogen. For instance, magnesium has a large natural solution pressure, or negative potential, of −1.55 volts. It tends to pass into solution readily, whereas gold, which is practically inert, has a positive potential of +0.98 volt.

An electrolyte is a conducting medium containing free

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W. E. Edwards is with the District Public Works Office, 14th Naval District, Pearl Harbor, T. H.

ions—a substance in solution which conducts electricity. It may be a liquid such as ocean water, or it may be a damp solid such as any conducting soil around an underground metallic structure.

An electric cell is a corrosive area or situation in which an electric potential is established. It occurs through the chemical action taking place between two electrically connected dissimilar metallic surfaces in contact with an electrolyte.

The metals below hydrogen in Table I are called anodic, base, or electronegative. Those above hydrogen are called cathodic, noble, or electropositive. However, any element in Table I is electropositive or cathodic to any element below it and is electronegative or anodic to any element above it.

The anode is always the electrode through which conventional direct current enters an electrolyte (or gas). In order for this current to exist, the anode is connected by a metallic conductor extending from the external source of electromotance or from the cathode. The direction of electric current is taken in the conventional direction, that is, it is opposite to the flow of electrons in a metallic conductor. The reason for this is that the conventional direction for electric current was conceived before very much was known about electrons.

In a common dry cell, the anode is the negative electrode or zinc shell. It is the electrode through which conventional current returns into the cell from the outside metallic circuit. A metal surface is said to be anodic when it is passing into solution by releasing positive ions. This leaves the residual metal electronegative, with the ability to supply electrons to the external metallic circuit.

TYPES OF METALS

AN ELECTRONEGATIVE METAL is one which carries a negative charge of electricity. It forms positive ions in a solution, resulting in a relatively negative electrode potential on the metal.

A base metal is one which has a relatively negative electrode potential, and enters readily into chemical combination with nonmetals. It has a low resistance to corrosive attack by acids and corrosive agents, and to atmospheric oxidation.

The cathode is always the electrode through which conventional direct current leaves an electrolyte (or gas). It is connected by a metallic conductor extending to the source of external electromotance or to the anode. In a common dry cell, the cathode is the positive electrode or center carbon rod. Outside the cell, the current direction is through a metallic circuit from cathode to anode, or from the positive to the negative electrode. Inside the cell, the current direction is through the electrolyte from anode to cathode, or from the negative to the positive electrode. A metal surface is said to be cathodic when it is collecting positive ions in a solution.

An electropositive metal is one which carries a positive charge of electricity. It supplies electrons to positive ions in a solution, resulting in a relatively positive electrode potential on the metal.

A noble metal or element is one which has a relatively positive electrode potential, and which does not enter readily into chemical combination with nonmetals. It has a high resistance to corrosive attack by acids and corrosive agents, and to atmospheric oxidation.

Although hydrogen commonly is shown in the potential series as the reference electrode, any other metallic element may be so taken. It is more convenient, in taking potential measurements on underground structures, to use a copper-copper sulfate "half-cell" as an actual reference electrode. Therefore, the copper electrode potential commonly is used as a reference point in cathodic protection work. Metals in the series below copper have a numerical negative potential difference approximately equal to that shown in Table I plus 0.35. Thus the solution potential of zinc (shown as -0.76), in relation to copper ($+0.35$), is -1.11 volts.

It is the anode metal which wastes away by releasing a flow of positive ions in solution. The term "ion flow" is usually considered to mean a flow of positive ions, also called cations. These cations are atoms of metal which have lost one or more electrons. Under the influence of a potential difference in an electrolyte, they migrate toward the cathode, thus effecting the transport of electricity. Consider a common dry cell which is producing current in an external circuit. Its zinc anode slowly wastes away under a potential difference between it and the carbon cathode of about 1.6 volts.

Similarly, a lead cable sheath acts as an anode and wastes away when submersed in an electrolyte in contact with a bare copper ground wire. It goes into solution by producing positive lead ions, and a primary cell is formed by the lead sheath and the copper wire. In this case, the solution potential is approximately 0.470 volt.

Two anodic metals also may interact with each other and form an electric cell. This occurs when a section of bright steel pipe is joined to an existing rusty steel pipe in damp, low-resistance soil. In this case, the bright steel is most anodic and the rusty steel becomes cathodic in relation to it. Although the solution potential between them may be barely 0.2 volt, the bright steel anode is slowly corroded. It releases more positive ions, and goes into solution as long as the potential difference and the conducting paths exist.

Any one of the metals below gold in the electrode-potential series, when immersed in a suitable electrolyte, can act as an anode. All that is necessary is to connect it electrically to another metal (placed in the same electrolyte) which is above it in the table.

ELECTROGENETIC CELLS

THE PRIMARY ELECTRIC CELL formed by two different metals acting as an anode and a cathode in an electrolyte, and connected electrically, is called an electrogenetic cell. That is, it generates electricity by causing a migration or flow of ions between two electrodes in a conducting solution. Corrosion from this cause is called electrogenetic corrosion.

Commercial examples of electrogenetic cells are the small flashlight cell, the larger dry cell, and the wet cell of an automobile battery, all used for low-voltage, direct-current requirements.

Another example of an electrogenetic cell is one formed by a magnesium or zinc anode buried in conducting soil and connected to a steel-pipe cathode. This is called a cathodic protection cell, since it is the pipe cathode which is being protected by the electrogenetic anode.

In underground pipe corrosion, electrogenetic cells are often formed naturally between various local metallic areas or electrodes on the pipe itself. A damp or conducting soil between them acts as an electrolyte. This action may be due to metal impurities (inclusions) or to the metal not being homogeneous in structure. High-purity iron will resist corrosion much better than low-purity iron. Cells as high as 0.5 volt also may exist as a result of nonuniform properties of the surrounding electrolyte. Cathodic areas are often formed on pipes in aerated sandy soils with anodic areas forming in lesser-aerated clay soils (Fig. 1).

The chemical energy of the electrolyte and electrodes is changed to electric energy the instant a metallic connection between the electrodes permits a current to exist.

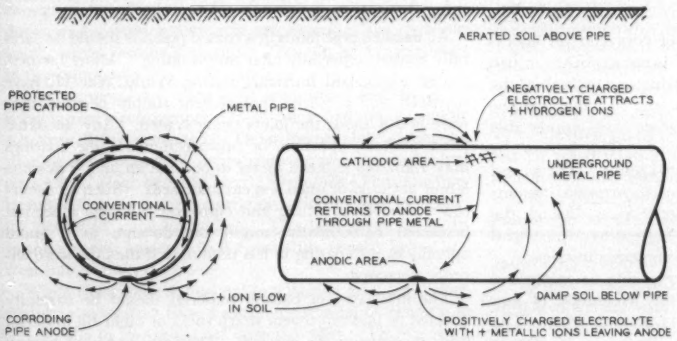
AERATED SOIL ABOVE PIPE
PROTECTED PIPE CATHODE
METAL PIPE
NEGATIVELY CHARGED ELECTROLYTE ATTRACTS + HYDROGEN IONS
CATHODIC AREA
UNDERGROUND METAL PIPE
CONVENTIONAL CURRENT
CONVENTIONAL CURRENT RETURNS TO ANODE THROUGH PIPE METAL
ANODIC AREA
+ ION FLOW IN SOIL
DAMP SOIL BELOW PIPE
CORRODING PIPE ANODE
POSITIVELY CHARGED ELECTROLYTE WITH + METALLIC IONS LEAVING ANODE

Fig. 1. Electrolytic action occurring in underground metallic structures.

There must be two current paths in any electric cell, one electrolytic and one metallic. In all of the foregoing cases, corrosion occurs at the anodes. On a metal pipe, the metallic path is provided by the pipe itself, and the electrolytic path is provided by the surrounding soil or water.

In another type of cell, electrolysis is carried out through the action of an electromotance entirely exterior to the cell itself. It is called an electrolytic cell in underground corrosion work. Corrosion from this cause is called electrolytic stray-current corrosion.

Electrolysis may be defined as the conduction of electricity in an electrolyte accompanied by the actual transfer of matter, the migration of ions in the electrolyte. This occurs in either the electrogenetic or the electrolytic cell. The occurrence of electrolysis is revealed by the chemical changes which take place at the electrodes.

However, electrolysis in the case of the underground corrosion electrolytic cell usually is thought of as being caused by an electromotance outside the cell. Such action might be due to the return current from a grounded battery, rectifier, or d-c generator. Such action always eats away or corrodes the anode and protects the cathode.

The "why" of electrolytic or stray-current corrosion can be better understood now that some of the electrochemical terms have been discussed.

Electrolysis takes place in both the electrogenetic cell and in the electrolytic cell. In the former case, the cell produces its own electricity. In the latter case, the electricity is provided from an outside source. The current sent through the ground by this outside source can cause considerable damage wherever it leaves a metallic surface.

A common case of electrolysis may be taken as an example. A d-c generator at an electric street-railway system powerhouse has its negative terminal solidly grounded as well as being connected to the steel rails. Its positive terminal connects to an insulated third-rail system or to an overhead trolley-wire system. The electric motor in each operating street car returns current from the third rail or trolley wire to the grounded steel rails.

However, all of this current does not necessarily travel from rail to rail until it reaches the powerhouse generator. Some of it takes an electrical short cut, since electricity flows over any available path, inversely in proportion to the path's electrical resistance. When the streetcar rails loop around three sides of a large square, some current usually jumps off into any metallic conductors buried along the fourth side. These may be water or gas pipes, steel ducts, or the metallic sheaths of underground telephone or power cables.

Eventually this stray current leaves each conductor to return to the rails or generator. If the area at which the current leaves is not electrically bonded to the rails (or generator negative terminal), it becomes an anode. Since it is the anode which goes into solution, the pipe surface, cable sheath, or other underground conductor rapidly pits or corrodes. This corrosion continues as long as the current flows, or until the unprotected cable or pipe fails and has to be dug up, repaired, or replaced.

The "how" of most underground corrosion is well established as an electrochemical reaction. It occurs through the slow wasting away of metals by electrical action in the presence of moisture and oxygen. As seen from the discussion of definitions and terms, the two essentials which allow the greater part of underground corrosion to occur are (1) a difference of electric potential between two metallic areas in contact with a conducting soil or water, and (2) the requirement of having a metallic as well as an electrolytic path between them.

The driving force which causes the corrosion is the voltage developed by the electrogenetic cell composed of the two

dissimilar metallic areas and the surrounding soil or electrolyte. The cell begins to operate as soon as a complete electric circuit connects the two metallic areas. On a single metal pipe in corrosive soil, the two metallic areas are always connected electrically. Corrosion starts as soon as the surrounding soil becomes damp enough to allow an electrolytic path to become established.

In nature, water always seems to be seeking a lower level. Likewise, a difference of electric potential always seems to be trying to neutralize itself over any paths available. The potential energy of a water reservoir is decreased (as its level is lowered) as water flows away from it under the influence of gravity. An electric potential between two connected underground metallic areas is neutralized (as chemical changes occur between them) due to electric currents flowing under the influence of ionization. When a difference of potential no longer exists, or when it has been neutralized by ion concentration or polarization, the current between the two metallic areas will stop. When it does, the corrosion it has been causing also stops.

HOW TO PREVENT UNDERGROUND CORROSION

THE PREVENTION or mitigation of corrosion on underground metallic structures usually is accomplished in two ways. The first method is by breaking one or both of the conducting electrical paths. These are the ionic and the metallic, both being necessary before any appreciable underground corrosion can take place. This is done by using protective coatings and insulated joints. The second method is by suppressing any natural corrosion currents which may be leaving metallic anodic areas through the surrounding soil. This is done by impressing an artificial underground current on them in the reverse direction.

There are two other aids in preventing or mitigating underground corrosion. One is the avoidance of any dissimilar metals in electrical contact with each other. The other is the avoidance of dissimilar electrolytes in contact with any metallic structure. The latter is accomplished largely by good drainage and by using selected backfill material.

An electron flow through a metallic pipeline may be the result either of stray-current pickup or of electrogenetic action between anodic and cathodic areas. These areas may be separated by many pipe lengths. In the latter case, the current between them can be broken by the installation of insulated flanges at flanged pipe joints. These consist of insulating gaskets and bushings. They must not be short-circuited with electrically conducting paint, piping, soil, or other materials, or the purpose of the installation will be defeated. However, some insulated fittings are purposely shunted with a resistor in order to pass a fixed amount of current for protection purposes. Others require bridging by lightning arresters in certain areas.

An electron flow resulting from stray-current pickup by an uncoated pipeline can also be controlled by insulated flanges. However, corrosion control by this method must be designed and supervised by cathodic protection engineers since there are numerous factors which have to be considered. These require considerable electrical measuring and testing which can be accomplished only by trained personnel using equipment designed for the purpose. If all possible electric paths are broken by insulation, no corrosion currents can flow through either the underground metallic structure or the surrounding soil.

If the metallic circuit alone is broken, the action is similar to that which occurs in a flashlight when the switch is turned off. The flashlight cell has an electric potential always ready to produce a current between anode and cathode. It is ready to act the instant the circuit is completed.

The ion flow from the outside surface of metallic structures can be nearly eliminated by the proper application of insulating coatings or wrappings. The ion flow from the inside surface of a metallic pipe into any electrically conducting liquid can also be reduced by the application of an insulating lining. Internally coated pipe may be prepared at the factory and shipped with reasonable safety. Pipe externally coated at the factory is more vulnerable to shipping and handling damage. It must be carefully handled, inspected, and repaired, both before and after being placed in the trench, if corrosion is to be prevented by the coating alone.

All finished pipe joints in a coated pipeline should be carefully coated, especially after any welding. Many factory-coated pipes, laid hurriedly during World War II, have corroded and required replacement simply because they were laid without the joints being coated. Any uncoated joint, pinhole, abrasion, or imperfection in pipe coatings may allow the exposed metal to become an anode to some larger abraded or uncoated cathodic area. Such an occurrence accelerates pitting and corrosion. A new pipe, not protected cathodically, might pit through at a small opening in the coating in less time than if the pipe were entirely uncoated.

The first layer of backfill material should be carefully selected or laid to prevent sharp rocks or other fill material from puncturing the coating. The importance of having a completely undamaged coating is very great in any pipeline which is not electrically protected. Even a tiny hole cut in the coating to determine thickness with a pit-depth gauge should be repaired after it has served its purpose.

If there is a difference in soil aeration at the top and the bottom of a pipe, anodic and cathodic areas may result. These often are separated by a distance of only half the pipe circumference. This often results in severe pitting along the entire bottom of a bare, poorly coated, or coating-damaged pipe. The bottom areas usually are more moist and form anodes. This is called electrogenetic corrosion, caused by one metal in two different concentrations of the same electrolyte (nonhomogeneous electrolyte). It is very important that great care be used in the selection and application of coating materials and the handling of the finished product. To insure longer life, a coated pipe should never be dragged or dropped into a trench or walked on after it is laid.

Sometimes a sharp cleavage in the type of surrounding soils occurs at the surface of a bare or poorly coated pipe. Anodic and cathodic areas may then form immediately adjacent, on each side of the cleavage. Anodic areas form in the area of the most corrosive soil. This is

called electrogenetic corrosion caused by one metal in different electrolytes. This type of corrosion may also occur where backfill material from different trench depths is indiscriminately mixed.

CATHODIC PROTECTION

AN AUXILIARY TYPE of protection to underground metallic structures is now being increasingly employed. It is known as cathodic protection, inasmuch as the devices employed make the metallic structure itself cathodic. It prevents corrosion currents from leaving naturally anodic areas, either through coating defects or from a bare pipe surface. It should be remembered that it is the anode which corrodes and cathode which is protected in any electric cell.

The destructive ion flow can be canceled by an equal and oppositely directed current, or it can be more than suppressed by a stronger opposing current. The corrosion currents leaving different areas (anodes) on a corroding underground structure vary in intensity. It is, therefore, customary to suppress them with an opposing current strong enough to be effective under all conditions. When this is done, and corrosion currents are reversed, the previous anodic areas become cathodes. This can be accomplished in two common ways.

The simplest, and often most economical method, is by using buried electrogenetic anodes connected to the metallic structure being protected. These expendable anodes are usually solid masses of magnesium or zinc in convenient sizes which weigh between 3 and 150 pounds. They also may be in the form of continuous ribbon weighing approximately 0.2 pound for each linear foot. This bare metal is buried in the ground, adjacent to the structure, usually below any frost line or plow depth.

When electrically connected to a rusting steel pipe, magnesium anodes may have a solution potential of as much as -1.3 volts in low-resistance corrosive soils. This causes a flow of ions away from the anodes toward the pipe. The strength of this flow depends on the relative areas of the two exposed metal surfaces, their proximity, and the conductivity of the surrounding soil. The ion flow gradually changes the electric potential between the pipe and the surrounding soil.

The pipe-to-soil potential is measured or compared by employing a device called a half-cell. It is used with a high-resistance voltmeter to compare the differences in electrode potential between the pipe and the half-cell placed in contact with the soil. The half-cell is a single electrode of an electrogenetic cell. This electrode is surrounded by a contacting electrolyte. It usually consists of a glass or plastic tube filled with copper sulfate electrolyte surrounding a copper electrode. It has a terminal connection at one end and an electrolyte-saturated wooden plug at the other end.

The ionic path in this measuring circuit is from the surface of the buried pipe through the soil to the saturated wooden plug. It then continues through the plug and through the electrolyte between it and the copper electrode. The electronic path is from the pipe through a connecting wire to the voltmeter. It then continues through the voltmeter and through another conductor to the copper sulfate electrode. The pipe is the other electrode of the electrogenetic cell.

Initially, an unprotected bright steel pipe buried in corrosive soil may have a pipe-to-soil potential of -0.79 volt. As corrosion currents or ion flows leave it, the pipe corrodes at anodic spots or areas. These chemical surface changes cause a change in solution pressure or potential. When the pipe surface has become generally rusted, the pipe-to-soil potential may be lowered numerically to -0.60 volt.

If cathodic protection is now applied to the rusted pipe, the destructive ion flow through the soil is reversed and the pipe anodes become cathodes. Polarizing electrochemical changes take place at the pipe surface, gradually raising its numerical solution potential. It is common practice to increase the pipe-to-soil potential numerically to a final average value of -0.85 volt. Another criterion is to increase it to a numerical value of 0.25 volt greater than the initial unprotected value. Corrosion on the pipe is then considered greatly reduced. It should be noted, however, that the potential of a pipe is only a qualitative indication of its condition with respect to corrosion.

Once an accepted voltage value is reached, the ion flow through the soil from electrogenetic anodes may be decreased. This is accomplished by inserting small resistors in series with the leads from the anodes to the pipeline or other metallic structure. If this is not done, the pipe-to-soil potential continues to increase toward the electrode potential of the electrogenetic anodes and little additional benefit is gained. The anodes merely expend themselves sooner and require replacement more frequently.

A good magnesium anode will generate (electrogenetically) approximately 500 ampere-hours for each pound of metal that is expended electrochemically through use. A 50-pound anode, with a capacity of 25,000 ampere-hours and generating 0.5 ampere continuously, will last for 50,000 hours, or for 5.7 years. If this current drain is reduced to 0.3 ampere, the same anode will last for approximately 83,333 hours, or for 9.5 years. Actually, the current decays as the anode is reduced in size, and each anode must eventually be replaced.

In addition to the use of buried electrogenetic anodes, underground corrosion currents are suppressed another way. This is done by using above-ground d-c generating sources connected to below-ground impressed-current anode beds. The d-c generating source is usually a rectifier rather than a mechanically driven generator. It must have an adequate means of adjusting the current output. The positive terminal is connected to a buried carbon, graphite, or metallic anode bed, and the negative terminal is connected to the metallic underground structure to be protected. This type of equipment is used where large protection currents are required and where a large spread or "throw" of underground current is desired.

In usual commercial sizes, carbon or graphite anodes are capable of discharging into the soil about one ampere for each square foot of anode surface area. Enough anodes are connected in multiple to discharge the required rectifier current output. The entire anode bed usually is placed

several hundred feet from the structure it is protecting. A scrap-iron or steel anode bed expends 20 pounds of metal per year for each ampere it continuously discharges into the soil. However, silicon-iron alloy impressed-current anodes are now available which expend less than one pound of metal per ampere per year.

These impressed-current systems must be carefully designed and installed. Their underground currents are more readily picked up (as stray currents) by other adjacent structures than are the currents from electrogenetic anode systems. A continuous protection current also is dependent upon a continuous supply voltage, whereas buried magnesium or zinc anodes generate continuously, throughout the lifetime of their metal. All cathodic protection anodes are expendable. It is, therefore, best to refer to the two types as electrogenetic (magnesium and zinc) and impressed-current anodes (graphite, silicon-iron alloy, etc.).

When an underground metallic structure in soils containing calcium is first subjected to protection currents, it is customary to apply them with high intensity. This deposits a calcareous coating on the metal. After such a coating has been deposited, along with other products of electrolysis, the combination acts to reduce the ion flow required to protect the structure. When this flow has been reduced to a minimum by a counter electromotance, the structure is said to be "polarized."

An effective way of decreasing underground corrosion is to avoid the use of dissimilar metals, either in proximity or in contact with each other. The rate of corrosion varies directly as the electrode potential difference and inversely as the soil resistivity and physical separation distance. It pays, therefore, to keep dissimilar metals as widely separated as possible. Even though not in direct contact when installed, two metal piping systems in proximity all too often do become connected. When this happens, accelerated corrosion of the more anodic metal results.

A copper water line can become connected to a steel gas pipe at a consumer's installation and cause electrogenetic corrosion of the gas pipe. This results from the action of two different metals in the same surrounding soil (electrolyte). Corrosion may occur where a lateral from one pipeline crossses under the other. If the soil conductivity is uniform, it may occur where the two pipes come closest together on the customer's property. In any case, maximum corrosion occurs at the anodic point or area where maximum current leaves the pipe, as a result of circuit resistance being the least. The remedy is to keep the two pipelines insulated from each other.

When two dissimilar metals are in contact and are exposed to an electrolyte, one is corroded more rapidly than if there were no contact between them. Electrical distribution or communication systems in underground ducts are subject to dampness or flooding. Bare copper or ground conductors should, therefore, not be run adjacent to lead-covered cables. For best results, wherever lead-sheathed cables are used, the adjacent conductors should be insulated.

If a bare copper conductor is used, it can cause pitting and puncturing of an adjacent anodic lead sheath in the presence of water. The consequent entrance of moisture may cause cable failure. Similarly, if a bare aluminum neutral conductor is used, it will corrode in the presence of moisture to protect the less anodic lead sheath. This may result in failure of the aluminum conductor. Failure of either a lead-covered cable or grounded neutral may result in serious damage and interruption to an electrical distribution or communication system.

Pipe failures caused by electrogenetic corrosion have occurred where pipes of different metal content in corrosive soils became connected accidentally. This may occur through discarded cans, broken pieces of pipe, and other metallic debris in the backfill. Where more than one coated pipe is laid in a trench, it may not be intended to bond them electrically. If so, great care should be taken that no metallic material is contained in the backfill. In fact, no debris or rubbish of any kind should be allowed in the backfill. Unfortunately, an open trench is often a tempting place for a contractor or his employees to get rid of building trash or other cleanup material. This may include plaster or cement leavings, pieces of metal lathing, sheet metal, fencing, pipe scraps, etc. When thrown into any trench containing metallic water, fuel, gas, telephone, or electric power lines, they can have a definitely damaging, corrosion-causing effect.

Also, the use of concrete around any underground iron or steel structure should be avoided unless the entire structure is encased in it. Steel encased in concrete is cathodic to bare steel. Cathodically protecting underground steel encased in concrete is a special problem. Protection currents of more than several milliamperes per square foot of steel surface should not be used. Otherwise they may weaken the bond between the steel and the concrete.

Where bare metal pipes are laid adjacent to each other in corrosive soils, they should all be of the same metallic structure. They should then be bonded electrically at regular intervals and protected cathodically as a unit.

CONCLUSION

Consideration in all underground construction projects should be given to the use of concrete, plastic, and other nonmetallic materials for pipelines and other structures. Where metals are used in proximity underground, they should be of the same homogeneous structure wherever possible. Dissimilar metals in underground contact should always be avoided. Wherever possible, underground metallic structures and pipelines should be thoroughly and carefully coated or wrapped before installation or backfilling. The materials used should be of proved electrical insulation and anticorrosion properties. Cathodic protection should then be applied as further insurance against corrosion in all corrosive soils. The protection may be in the form of an electrogenetic-anode system or an impressed-current system.

An understanding of the electrochemical principles and elements involved in this study of corrosion should be of considerable help to all design, construction, inspection, operation, and maintenance people. It is presented for the benefit of all who are interested in reducing the large annual costs of the ravages of nature on man-made underground metallic installations.

Determining Fourier Series Coefficients Graphically

W. H. MIDDENDORF
MEMBER AIEE

THE ACCURACY of the Fourier series coefficients when determined by the equation[1]

$$B_n = \frac{2}{m}\sum_{1}^{m}\left[y_k \sin n\left(k-\frac{1}{2}\right)\frac{2\pi}{m}\right]$$

should receive some consideration.

A saw-tooth wave was analyzed using the equations given above and the error in the coefficients determined. Table I shows that the error in B_{10} when using 50 segments is about equal to the error in B_5 when using 25 segments, or the error in B_1 when using 5 segments. Notice also that if only eight segments are used to determine B_5 the error is 117 per cent. These errors are not caused by inaccuracies in determining y_k, as the exact value was found in each segment and, for this wave, the midpoint value is the true average. These errors are caused by using large segments compared to the period of the harmonic whose coefficient is sought.

A new method of determining the Fourier series coefficients is made possible if the number of segments is changed so as to be a multiple of the harmonic number as each coefficient is computed. If this is done, literal equations can be developed for the average ordinate of each segment of the $y \sin nx$ curve. These equations involve numbers determined by the nonsinusoidal wave and multipliers whose

Table I. Errors in Fourier Coefficients of a Saw-Tooth Wave when Using the Method of Rectangular Summation

Number of Segments	Per Cent Error in B_1	Per Cent Error in B_5	Per Cent Error in B_{10}
50	...	...	6.9
40	...	...	10.7
25	...	7.5	...
20	...	11.3	57.0
10	...	57.3	...
8	...	117	...
5	6.8	...	...

values are determined by the particular part of the harmonic wave that exists within the various segments. The equations are developed by considering a typical segment as shown in Fig. 1. The area under the nonsinusoidal wave can be divided into the area below the nonsinusoidal function but above the straight line drawn between points at the limits of the segment and the area below the straight line but above the abscissa. The former area is approximately equal to the area enclosed by a parabola[2] whose vertex is δ units above the abscissa. The latter area is exactly equal to that of a trapezoid bounded by the straight line, the segment limits, and the abscissa. The average ordinate of this typical segment is given by:

$$O_s = \rho\alpha + \sigma\beta + \tau\delta$$

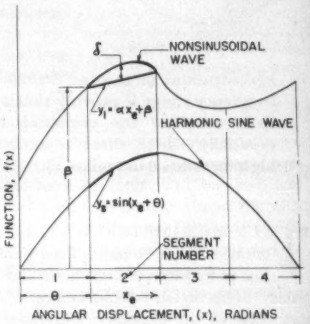

Fig. 1. Typical segments of nonsinusoidal wave and harmonic sine wave.

where

α = slope of the straight line y_1
β = intercept of the straight line y_1 at the left-hand edge of the segment
δ = height of the parabola as shown in Fig. 1
and ρ, σ, τ are multipliers whose values depend upon the portion of the harmonic sine wave within the segment.

The coefficient of the nth harmonic sine term is then given by

$$B_n = \frac{2}{m}\sum_{1}^{m} O_s$$

This method, when applied to a saw-tooth wave using five segments, yields the value of the fifth harmonic sine term coefficient with an error of 0 per cent. Other waves have been analyzed by this method. The largest error experienced in those problems wherein the accuracy was tested was 3 per cent. The only disadvantage of the method is the number of computations necessary if the number of segments chosen must be greater than 1 or 2 for each cycle of the harmonic whose coefficient is sought. Inasmuch as the number of segments is most likely to be equal to the harmonic number when the higher order harmonics are desired, it is proposed that the method described here be used to find the Fourier series coefficients of the higher harmonics.

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Digest of paper **56-684**, "Graphical Determination of the Fourier Series Coefficients," recommended by the AIEE Committee on Basic Sciences and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer and Pacific General Meeting, San Francisco, Calif., June 25–29, 1956. Scheduled for publication in AIEE *Communication and Electronics*, 1956.

W. H. Middendorf is with the University of Cincinnati, Cincinnati, Ohio.

Millimeter Waves and Their Applications

R. G. FELLERS
MEMBER AIEE

Investigations in the vast 30,000- to 300,000-mc frequency range is proving that it can accommodate many of the communications services, especially where there is need for high-gain, high-directional antennas, and large bandwidth.

THE MILLIMETER WAVELENGTH RANGE is defined as that extending from 1 to 10 mm, corresponding to frequencies of 300,000 and 30,000 mc, respectively. This region bridges an appreciable portion of the gap between the presently used radio spectrum and the infrared (wavelengths about 0.1 mm). Its lower frequency limit is just above the highest frequency employed during World War II, and its upper frequency appears to be about the limit of presently known microwave techniques.

INTEREST IN THIS FREQUENCY RANGE

THERE ARE MANY REASONS for the investigation and exploitation of this wavelength range, aside from the natural tendency to fill the gap between two usable portions of the electromagnetic spectrum. With every passing year, new military and civilian needs are found for the available spectrum, and greater and greater bandwidths are required for existing services. Use of these high frequencies can, at least potentially, relieve some of this pressure and accommodate some of these services. The vast frequency range between 30,000 and 300,000 mc represents ten times as much bandwidth as is currently in use. Increased use of short pulses and other wide-band modulation in television, radar, and communications systems not only requires large bandwidth, but makes high carrier frequencies extremely attractive.

Antenna Size and Gain. The short wavelength of this region permits the operation of highly directive antennas of relatively small physical size. A parabolic antenna 2 feet in diameter has a power gain of approximately 50 db at a wavelength of 5 millimeters. For an actual transmitter power of 10 milliwatts, this yields an effective radiated power of 1 kw. This same reflector provides an antenna beamwidth of 1/2 degree.

Atmospheric Effects. Propagation characteristics unique to the millimeter range require special consideration in discussing possible applications. Molecular resonance and absorption by atmospheric gases are encountered in this region, as is increased scattering and reflection from rain, snow, and fog. Fig. 1 contains a plot of attenuation versus wavelength from 1 to 25 mm. This graph shows attenuation caused by water vapor and oxygen, which are the only atmospheric gases having significant effect. The absorption peak at 1.25 cm is caused by water vapor and those at 5 and 2.5 mm are caused by oxygen.[1,2]

In ignorance of this absorption data, a wavelength of 1.25 cm was chosen for radar use in the latter part of World War II. As can be seen from the curves, this is very close to the water-vapor absorption peak and, as a result, this radar was comparatively ineffective in areas of high humidity. One desirable outcome of this otherwise unfortunate choice was the stimulation of interest in the investigation of the phenomena of molecular absorption at this and nearby wavelengths.

On the basis of the data presented in the foregoing, it is apparent that a choice of approximately 8.5-mm wavelength is desirable for radar and general use, where maximum propagation distance is desired. Another suitable choice would be 3.75 mm, but generation and transmission difficulties at this wavelength have not yet been fully overcome.

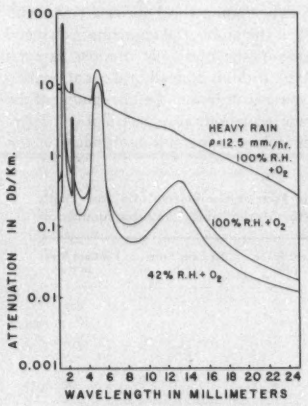

Fig. 1. Atmospheric attenuation wavelength.

If for some reason it is desired to limit the distance from the transmitter at which a signal can be satisfactorily received, a choice of 5 mm is indicated. At this wavelength, there is an attenuation of about 15 db per km because of

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Full text of a special article recommended by the AIEE Committee on Radio Communications Systems.

R. G. Fellers is with the University of South Carolina, Columbia, S. C.

This article contains discussion of the work of many investigators; the list of references gives proper credit to some of them.

magnetic moment absorption by the oxygen molecule. It is evident that a very few kilometers of atmosphere will provide a very effective blanket to radiation of this wavelength.

The selection of short wavelengths encounters an additional difficulty in scattering and absorption by condensed water drops as the wavelength approaches drop dimensions. At a wavelength of 6 mm, this results in an attenuation of about 1.5 db per km for a moderate rain (4 mm per hour). Heavy rains (12.5 mm per hour) occurring only for an hour or two annually in temperate climates result in an attenuation of about 5 db per km at this wavelength.[3]

As it consists of condensed water droplets, fog displays a similar effect on propagation. A heavy fog (visibility about 400 feet) gives rise to an attenuation of about 0.3 db per km.

Inasmuch as ice has much lower dielectric and absorption constants than liquid water, the effect of snow is much less than that of rain and usually may be neglected. As a result of these facts, the usefulness of millimeter wavelength equipment in bad weather may be limited, although these properties render this wavelength range particularly well adapted for cloud- and rain-detection radar.

Basic Research. Microwave spectroscopy, particularly in the millimeter wavelength range, has proved an extremely valuable tool in the investigation of molecular structure. Literally hundreds of spectral lines have been observed and molecular properties computed. The microwave spectrograph is particularly useful, because of its extremely high resolving power, caused largely by the precise single-frequency sources available.

Additional basic scientific information of interest and value in the fields of solid-state theory and superconductivity can be obtained by investigations in the millimeter-wavelength region. The classical experiments have indicated that superconductivity has not been detected at infrared wavelengths (0.01 mm). In the past, superconductivity measurements have been made at several hundred megacycles and more, and recently at frequencies as high as 24,000 mc, indicating that this phenomenon is still observed at high microwave frequencies. The transition from the conducting to superconducting region may well occur in the millimeter wave range and constitutes a fruitful field of research.

SOURCES OF MILLIMETER WAVE ENERGY

Before any scientific investigation or applications can be effected in any frequency range, power sources are necessary. Early investigators considered the possibility of multiple spark-gap discharges between metal balls or mercury droplets as a source of energy. These have yielded very small amounts of power spread over a considerable frequency range and have proved to be of little value. Other power sources have included harmonic output of low-frequency oscillators and frequency multiplication from a low frequency using crystals or other nonlinear devices as harmonic generators. This latter method has been made to function for second harmonic production with efficiencies of several per cent at 60,000 mc, providing sufficient power for some purposes such as microwave spectroscopy. Available power from this source generally is inadequate for use.

Conventional Microwave Oscillators. As is to be expected, the most fruitful avenue of approach has been the extension of the usefulness of microwave oscillators such as klystrons, magnetrons, and traveling wave tubes to the millimeter range.[4]

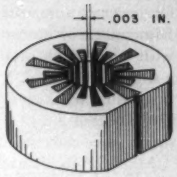

Fig. 2. Rising-sun anode of millimeter magnetron.

Reflex klystrons have been developed in the frequency range from 26,000 to 60,000 mc, yielding power outputs ranging from 30 milliwatts at the lower frequency limit down to about 5 milliwatts at 60,000 mc. These power levels are adequate for most local oscillator and measurement applications and are believed to represent almost the ultimate in klystron development. Klystrons for use at 60,000 mc are characterized by close tolerances, excellent surface finishes, and involved fabrication techniques.

Pulsed magnetrons have proved to be better adapted for short-wavelength use. Peak power levels of 100 kw at 6.3 mm and 20 kw at 3.3 mm have been obtained. Detectable power has been observed at 1.1 mm. These tubes have generally employed the rising-sun anode structure which is constructed with extremely thin vanes. Fig. 2 depicts the anode structure of a typical millimeter magnetron.

Traveling-wave amplifiers using helix and waveguide structures have been used to deliver 10 milliwatts of continuous wave power at 5 mm. Backward wave oscillators using structures of the helical and space harmonic type have been operated at wavelengths of 3.0 mm. It appears that tubes of this type show the greatest promise for further extension of the frequency spectrum.

INSTRUMENTATION, DETECTION, AND TRANSMISSION

Rectangular Waveguide. The use of rectangular waveguide in the TE_{10} dominant mode is not attractive for transmission over considerable distances because of very high attenuation. In spite of this fact, many necessary functions are most suitably performed in this guide when the lengths involved are small. Utilizing this type of guide antenna, feeds, detectors, and test equipment of all kinds have been developed for use in the millimeter region. Items which have been developed included slotted lines, directional couplers, attenuators, low Q and high Q wavemeters, crystal mounts, bolometer mounts, bends, twists, tees, and tuners. Fig. 3 contains photographs of typical pieces of millimeter test equipment.[5,6] Components for use in the 26,000- to 40,000-mc range are commercially available from several manufacturers.

In the design of these components, severe problems of small dimensions, close tolerances, and good surface finishes are encountered. Anyone who has experience with microwave devices will recall the problems of eliminating slope and slot radiation and maintaining tolerances in a 3.3-cm slotted line. Difficulties are multiplied by a factor of 7 at 5 mm. A slot width of 0.090 inch becomes one of 0.013 inch. A tolerance of 0.001 inch on slope becomes a tolerance of 0.00014 inch. Construction of these devices becomes a job

for jewelers and watchmakers rather than for machinists. Dimensions of waveguide components are scaled linearly with wavelength, and tolerances should also be scaled in a similar manner. A precision cavity for use at 3.3 cm can be constructed with a tolerance of 0.0001 inch, but at 5 mm the required tolerance becomes 0.000015 inch, which is much more difficult to attain.

Many of the fabrication problems have been solved by extensive use of the electroforming process. Ordinary components such as bends, twists, tee junctions, and directional couplers have been electroformed on silvered polystyrene mandrels, which are later removed by a suitable solvent. Excellent surface finishes and tolerances of better than 0.001 inch have been obtained in this way. The plastic mandrel and a resulting directional coupler manufactured in this way are shown in Fig. 4. Precision wavemeter cavities have been electroformed on ground, polished molybdenum mandrels with a mirror-like finish and tolerances of 25 microinches.[7]

Detection and Power Measurement. For the measurement of power, bead thermistors and bolometers of the fine wire or film type are used extensively with conventional bridge circuits. Crystal detectors appear to provide the most satisfactory millimeter receivers and are also applicable to relative power measurement. In order to minimize lead losses and matching difficulties the semiconducting element is usually mounted directly in a waveguide of the appropriate size. Some investigation of infrared detectors has been carried out, but sensitivity comparable with that of crystal detectors has not been attained.

ALTERNATIVE TRANSMISSION METHODS

Circular Waveguide. Attenuation of the dominate TE_{10} mode in standard rectangular waveguide is approximately 70 db per hundred feet. Considering two-way transmission over a 100-foot line, this reduces the effective power output of a 10-megawatt radar transmitter to 0.1 microwatt. It is apparent that this situation cannot be tolerated and extensive research into alternative transmission methods has been instituted. The TE_{01} mode in circular waveguide has long been attractive because of the fact that its attenuation decreases steadily with increasing frequency. This mode has circular electric field lines and no wall currents in the direction of propagation. Field configuration of this mode is shown in Fig. 5. Theoretical values of attenuation for a two-inch diameter pipe operated at 50,000 mc are as low as 2 db per mile, and experimental studies indicate that an attenuation of 3 db per mile can be attained. Smaller diameter guides readily result in values of attenuation in the vicinity of several db per hundred feet, which is suitable for most system applications. This mode is particularly suited to the design of rotary joints and connectors because of its circular symmetry and the fact that there is no axial component of current in the walls. Some difficulties are encountered in excitation, detection, and transmission around bends. Bends excite the degenerate TM_{11} mode which extracts power from the desired mode and does not have its low attenuation characteristics. A partial solution of this problem has been achieved by using only large radius bends or ring structures in the bend. The latter method introduces some loss. Excitation of this mode has been accomplished by distributed exciters of considerable length and by multiport junctions. Narrow bandwidth of the second of these alternatives indicates the need of further work in this field.[8]

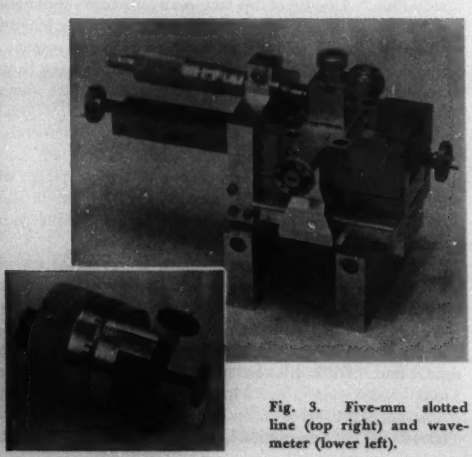

Fig. 3. Five-mm slotted line (top right) and wavemeter (lower left).

Dielectric Waveguide. Another extremely attractive means of obtaining low loss transmission is the use of dielectric-rod waveguide in the hybrid dipole mode. If the diameter of the rod is made a small fraction of a wavelength, extremely low loss is obtained. Attenuation is very sensitive to rod diameter and varies from 0.12 db per hundred feet for a diameter to wavelength ratio of 0.2, up to 106 db per hundred feet for a ratio of 0.8. In the low attenuation case the field extends to a radius of about 2 inches before it is down to 10 per cent of its value at the surface of the guide. These data are for polystyrene at a wavelength of 1.25 cm. A number of disadvantages to the use of this scheme are apparent. For low values of attenuation, the field extends a considerable distance around the rod, and bends introduce radiation. An exciter comparable to the extent of the field is necessary. These problems become less severe at extremely short wavelengths, as both the rod and the extent of the field are small.[9,10]

Considerable use of this type guide has been made, with the diameter so chosen as to yield only moderately low figures of attenuation. It provides an excellent flexible waveguide for laboratory use and is susceptible to simple construction of directional couplers and hybrid junctions.[11]

Another possible approach to the transmission problem lies in the use of optical methods, including highly directive lenses, reflectors, and prisms for the transmission of energy over short distances. This scheme has not been fully investigated.

APPLICATIONS

IT IS NOW APPROPRIATE to give some consideration to fields in which the particular properties of millimeter wavelength energy can be applied profitably.

The short wavelength makes a highly directive antenna possible with moderate physical dimensions. Any system in which high directivity is desirable, such as fire control radar, can make use of this fact. High antenna gain makes possible communication over considerable distances with milliwatts of transmitter power. In any application in which moderate antenna gain and directivity are desired, accompanied by minimum size, the use of millimeter waves become almost mandatory. Obvious applications include small ships, submarines, and piloted or pilotless aircraft.

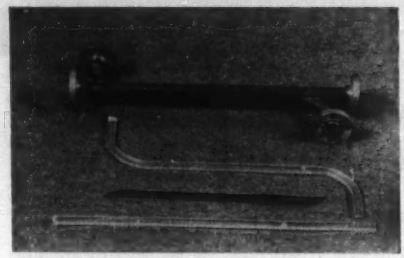

Fig. 4. Plastic mandrel and the resulting directional coupler.

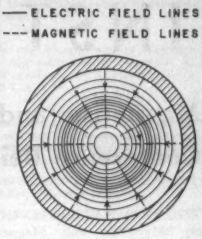

Fig. 5. Field configuration of TE_{01} mode in wave-guide.

Short-pulse and wide-band systems require large bandwidths, readily is available in this frequency range. Design is facilitated by the fact that a large absolute bandwidth can still be a small percentage bandwidth. If for some reason it is desired to limit the range at which a signal is to be detectable, the high oxygen absorption at a wavelength of 5 mm then may be used to produce extreme range limitation unaffected by anomalous propagation conditions. A possible application of this might be the prevention of interference between two services operating on the same frequency.

The high reflection properties of water drops in the millimeter range make it particularly adaptable for meteorological uses, such as the detection of rain and clouds.

Attenuation figures of 3 db per mile attained in circular waveguide of small size at 50,000 mc suggest the possibility of using this means to replace coaxial cables and radio relay links for long-distance television and telephone transmission. Such a system combines the weatherproof features of the coaxial line with the high r-f advantage of the relay link. This latter property permits the simultaneous transmission of a large number of television programs.

In summary, it may be said that millimeter waves will find their place in any application where high-gain high-directivity antennas of small size are needed or where large bandwidth is desired.

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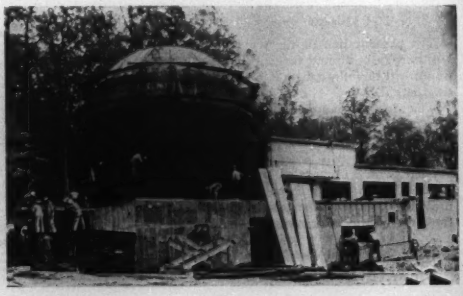
Major Component of Atomic Plant Nears Completion

Welders put finishing touches on steel shell for the vapor container of the Army Package Power Reactor (APPR), one of the nation's first atomic generating plants.

The vapor container is 64 feet high and 36 feet in diameter with walls of $^7/_8$-inch steel plate that will be reinforced with 2 feet of concrete. The APPR, which ALCO Products, Inc., Schenectady, N. Y., is building at Fort Belvoir, Va. for the Atomic Energy Commission, is expected to be in operation early in 1957. It is a 2,000-kw pressurized-water-type plant, designed so that components may be carried by air anywhere in the world and assembled to produce electrical energy through nuclear action. The Fort Belvoir installation will be used to train military personnel.



INSTITUTE ACTIVITIES

Magnetism and Magnetic Materials Conference Being Held October 16–18

THE 2ND NATIONAL CONFERENCE on Magnetism and Magnetic Materials will be held at the spacious Hotel Statler in Boston, Mass., October 16–18, 1956. This conference is sponsored by AIEE with the co-operation of the following societies: American Physical Society (APS), American Institute of Mining, Metallurgical and Petroleum Engineers (AIME), and the Institute of Radio Engineers (IRE).

The purpose of the conference is to provide an opportunity for the presentation of papers and discussions of both the theoretical aspects of magnetism and its practical applications. The broad scope of the program, combined with the exhibits of leading manufacturers, provides a common meeting ground for people of widely different interests; manufacturers, fabricators, users, as well as research personnel in these fields.

Registration

Registration will take place at the Hotel Statler Mezzanine from 8 a.m. to 5 p.m. on Tuesday, October 16, and from 8:45 a.m. to 5:00 p.m. on Wednesday and Thursday. Admission badges will be ready for preregistrants, without waiting. You will conserve your time and assist in conference planning by registering in advance.

When doing so, please indicate clearly name, company and position, business address, and society affiliation, i.e. AIEE, APS, AIME, or IRE.

The registration fee of $5 includes admission to the technical sessions, the magnetics exhibit, and the informal get-together Tuesday evening. The cost of the dinner on Wednesday is $6 and the proceedings of the conference are $4 if ordered before October 18. The price of the proceedings will be $7 if purchased after October 18.

Checks should be made payable to the Conference on Magnetism and mailed to T. O. Paine, General Electric Company, West Lynn, Mass. Please return registrations at earliest possible date. Attendance at dinner is limited to the first 300 reservations received.

Technical Sessions

The presentation of the technical papers will be rigidly limited to 12 minutes. Each paper will be followed by a 3-minute discussion period.

The meeting rooms will be provided with a standard slide projector for $3^1/_4$ by 4-inch slides, blackboard, and a reading stand. Other facilities will be available by special arrangement. Completed papers, for publication in the Conference Proceedings, must be handed to the session chairman at the time of the presentation.

Informal Get-Together

A party is scheduled for 8:30 to 11:30 p.m., Tuesday evening in the Bay State Room to provide a gathering place to become acquainted with other registrants for informal discussions. Light refreshments will be served. Admission is by registration badge.

Dinner

A roast beef dinner, preceded by a social gathering at 6:30 p.m., will be served at 7:15 p.m. in the Morse Auditorium of the Boston Museum of Science, one of Boston's finest examples of modern architecture. After dinner, Dr. R. M. Bozorth of the Bell Telephone Laboratories will present a talk, illustrated with color slides, on his recent visit to the U.S.S.R. to attend a conference on The Physics of Magnetic Phenomena." Dr. Bozorth will discuss Soviet progress in magnetic research as well as the social life he and his wife observed on their trip through the country. In addition to attending the technical conference, they also visited state nurseries, elementary schools, universities, an atomic power plant, and resort areas.

Due to space restrictions, attendance is limited to 300 people. Tickets at $6 will be sold in advance, and any tickets remaining will be sold at the registration desk on a first come, first served basis.

Committee Meetings

The local committee will meet at the Hotel Statler at 8 p.m. on Monday, October 15. The Magnetics subcommittee will hold a luncheon meeting, 12:30 to 2:00 p.m. on Thursday, October 18, in the Hotel Statler.

Conference Proceedings

The proceedings will be printed immediately after the conference and will contain all of the technical papers presented. If ordered before the end of the conference, the price will be $4; after October 18, $7.

Hotel Reservations

Accommodations are available at Conference Headquarters, the Hotel Statler. Other nearby hotels are the Sheraton Plaza, the Lincolnshire, and the Bradford.

Magnetics Exhibit

A magnetics exhibit on the mezzanine has been arranged with some of the country's outstanding firms engaged in research, manufacture, and application of magnetic materials, components, and equipment. These include:

Arnold Engineering Company, Marengo, Ill.
Magnetic materials: permanent magnets, high permeability cores

Bell Telephone Laboratories, Inc., Murray Hill, N. J.
Magnetic materials in communications equipment

The Carpenter Steel Company, Reading, Pa.
High nickel alloy parts for: temperature compensator alloys, low expansion alloys, glass sealing alloys

Crucible Steel Company of America, Pittsburgh, Pa.
Magnets, magnet assemblies, precision instrument castings

General Electric Company, Metallurgical Products Department
Permanent magnets, thermistors, thyrites

General Electric Company, Research Laboratories
New scientific equipment and demonstrate properties of new materials

General Magnetic Corporation, Detroit, Mich.
Alnico magnets

The Indiana Steel Products Company, Valparaiso, Ind.
Permanent magnets, nonmetallic ceramic permanent magnets, speaker magnets

Instruments Publishing Company, Pittsburgh, Pa.
Instruments and Automation magazine; "Instrument and Apparatus News," technical book

Magnetic Metals Company, Camden, N. J.
Electromagnetic core parts and shields

Magnetics, Inc., Butler, Pa.
Tape wound cores: ultrathin cores, shields, laminations, powered permalloy cores

Radio Frequency Laboratories, Boonton, N. J.
Models *942* and *107* Magnet chargers, Model *889* Magnetreater, Model *206* Booster Unit, Model *1221* Charger

Rese Engineering, Inc., Philadelphia, Pa.
Magnetic core pulse analyzer for analyzing square-loop magnetic cores; automatic handler for high speed testing of cores

Westinghouse Electric Corporation, Pittsburgh, Pa.
Specialty transformers and Hipersil cores, magnetic materials

The exhibit hours are from noon to 8 p.m. on Tuesday and Wednesday and from noon to 6 p.m. on Thursday, October 18.

Committee

The General Chairman of the Conference is R. M. Bozorth. Members of the program committee are C. P. Bean, chairman; Mr. Bozorth; H. Brooks; D. R. Brown; J. E. Goldman; W. R. Hibbard, Jr.; J. A. Osborn; and G. T. Rado. The local conference committee is made up of T. O. Paine, chairman; F. E. Luborsky; N. Menyak, and R. Lever, arrangements; E. Yamartino, publicity; D. McMurtrie, and F. Luborsky, finance; J. Osborn, exhibits; W. Klawitter, and L. Mendelsohn, dinner. R. Rimbach of Richard Rimbach Associates, is manager of exhibits.

Society representatives are R. S. Gardner, AIEE; J. E. Goldman, APS; W. R. Hibbard, Jr., AIME; and D. R. Brown, IRE.

Members of the AIEE Subcommittee are J. E. Goldman, chairman; R. A. Chegwidden, secretary; A. C. Beiler; C. P. Bean; L. R. Bickford; E. Both; F. Brockman; H. Brooks; E. A. Gangler; C. L. Hogan; Z. E. Legg; M. F. Littman; L. R. Maxwell; C. A. Maynard; W. F. Meiklejohn; W. Morrill; J. A. Osborn; T. O. Paine; and G. T. Rado.

The tentative technical program for the Conference on Magnetism and Magnetic Materials follows.

Tuesday, October 16

8:00 a.m. Registration

9:00 a.m. Session I—Magnetic Anisotropy—Georgian Room

Opening Remarks and Welcome: R. M. Bozorth, conference chairman

Presiding: J. E. Goldman

***A Survey of the Theory of Magnetic Anisotropy.** *J. H. Van Vleck*, Harvard University

A New Magnetic Anisotropy. *W. H. Meiklejohn, C. P. Bean*, General Electric Research Laboratories

Controlled Crystal Anisotropy of Various Mixed Ferrites. *C. M. van der Burgt*, Philips Research Laboratories

Semicovalence and Anisotropy in Magnetic Oxides. *A. L. Loeb, J. B. Goodenough*, Lincoln Laboratory

Intermission

***Magnetic Annealing.** *R. M. Bozorth*, Bell Telephone Laboratories

Magnetic Domain Patterns on Thin Films. *R. C. Sherwood, H. J. Williams*, Bell Telephone Laboratories

Magnetization of Nickel Films at Low Temperatures. *R. W. Hoffman, A. M. Eich*, Case Institute of Technology

On the Determination of Magnetocrystalline Anisotropy Constants from Torque Measurements. *J. S. Kouvel, C. D. Graham, Jr.*, General Electric Research Laboratories

2:00 p.m. Session II—Permanent Magnets and Fine Particles—Georgian Room

Presiding: R. M. Bozorth

***Fine Particle Magnets.** *T. O. Paine*, General Electric Company

Magnetic Properties of Some Iron and Iron Oxide Micropowders. *R. B. Campbell, H. Amar, A. E. Berkowitz, P. J. Flanders*, The Franklin Institute Laboratories for Research and Development

Determination of the Orientation of Crystallites in Elongated Particles in the Single-Domain Range. *R. B. Campbell*, The Franklin Institute Laboratories for Research and Development

The Magnetic Properties or Single-Domain Cobalt-Iron Particles with Pronounced Shape Anisotropy. *F. E. Luborsky, L. I. Mendelsohn, T. O. Paine*, General Electric Company

Magnetic Anisotropy and Rotational Hysteresis in Elongated Fine Particle Magnets. *I. S. Jacobs*, General Electric Research Laboratories; *F. E. Luborsky*, General Electric Company

The Relation between Magnetic Properties and Crystal Morphology of Submicron Iron Crystals. *M. W. Freeman*, M. W. Freeman Company; *J. H. L. Watson*, Edsel B. Ford Institute for Medical Research

Intermission

A Contribution to the Study of Permanent Magnets of the Fe-Co-Ni-Al Type. *A. J. J. Koch, M. G. v.d. Steeg, K. J. deVos*, Philips Research Laboratory

Nucleation Experiments on Alnico 5. *E. A. Nesbitt, A. J. Williams*, Bell Telephone Laboratories

Processing and Properties of Cobalt-Platinum Permanent Magnet Alloys. *D. L. Martin*, General Electric Research Laboratories

Effects of Temperature Variations on the Remanence of Permanent Magnets. *R. K. Tenzer*, The Indiana Steel Products Company

Stress Corrosion in Permanent Magnets Composed of Anisotropic Powdered Manganese Bismuthide. *E. Adams*, U. S. Naval Ordnance Laboratory

Wednesday, October 17

9:00 a.m. Session IIIa—Magnetism and Physical Metallurgy—Georgian Room

Presiding: W. R. Hibbard

***Magnetism and Structure.** *C. Zener, R. R. Heikes*, Westinghouse Research Laboratories

A Neutron Diffraction Study of the Structures and Magnetic Properties of Manganese Bismuthide. *B. W. Roberts*, General Electric Research Laboratories

The Magnetic Structure of Annealed Fe_3Al. *R. Nathans, M. T. Pigott*, Pennsylvania State University; *C. G. Shull*, Massachusetts Institute of Technology

Some New X-ray Data on Iron-Rich Iron-Aluminum Alloys. *A. Taylor, R. M. Jones*, Westinghouse Research Laboratories

Effect of Atomic Ordering on Magnetic Properties of 10 to 17 Per Cent Aluminum-Iron Alloys. *D. Pavlovic, K. Foster*, Westinghouse Electric Corporation

Intermission

Heat Treatment for High Initial Permeability in Binary and Complex Nickel-Iron Alloys Containing about 75 Per Cent Ni. *R. E. S. Wolters*, Post Office Engineering Department, Research Branch, Dollis Hill, London, N. W. 2

Magnetostriction Measurements on Some Ordered and Disordered Fe-Pt Alloys. *E. Klokholm, F. J. Donahoe*, The Franklin Institute Laboratories

Magnetic Measurements of Ni-Au Alloys. *A. E. Berkowitz, P. J. Flanders*, The Franklin Institute Laboratories for Research and Development

Magnetization of Cr-Rich Fe-Cr Alloys from 2°K to 300°K. *A. Arrott*, Carnegie Institute of Technology

A Magnetic Method for the Measurement of Precipitate Particle Sizes in a Copper-Cobalt Alloy. *J. J. Becker*, General Electric Research Laboratories

Magnetic Properties of UMn_2. *A. R. Kaufmann, S. T. Lin*, Massachusetts Institute of Technology

Strong Field Cryomagnetic Studies of Some Ferromagnetics, Ferrimagnetics and Antiferromagnetics. *W. E. Henry*, U. S. Naval Research Laboratory

9:00 a.m. Session IIIb—Apparatus and Design—Bay State Room

Presiding: J. A. Osborne

Magnetoabsorption. *W. E. Bell*, Varian Associates

Power Comparing Calorimeter. *E. R. Czerlinsky, R. A. MacMillan*, Air Force Cambridge Research Center

Instrumentation for Magnetic Moment and Hysteresis Curve Measurements. *P. J. Flanders*, The Franklin Institute Laboratories for Research and Development

A Simple Method to Calculate Leakage Factors for Magnetic Circuits with Permanent Magnets. *R. K. Tenzer*, The Indiana Steel Products Company

Instrumentation for and Measurement of Magnetostriction at Low Alternating Field Intensities in Silicon Iron. *C. W. Little, Jr., D. A. Wycklendt*, Allis-Chalmers Research Laboratory

Intermission

Investigation of an Alternating-Current Bridge for the Measurement of Total Core Losses in Ferromagnetic Materials at High Flux Densities. *I. L. Cooter, W. P. Harris*, National Bureau of Standards

A New Ferroresonance Combination for Static Control Devices. *A. T. Balint*, University of Buffalo

New D-C Hysteresigraph. *J. D. Young*, General Electric Company

An Automatic Torque Balance for the Determination of Magnetocrystalline Anisotropy. *R. F. Penoyer*, International Business Machine Corporation

2:00 p.m. Session IVa—Losses in Soft Magnetic Materials—Georgian Room

Presiding: C. P. Bean

***The Origin of Losses in Magnetic Materials.** *J. Goodenough*, Lincoln Laboratories

The Effect of Impurities and Orientation on the Losses in Silicon Iron. *G. W. Wiener*, Westinghouse Electric Corporation

The Effect of Plastic Deformation on the Core Loss of Oriented Silicon Steel. *J. K. Stanley*, Crucible Steel Company of America

Domain Observation on Silicon-Iron. *C. D. Graham, Jr.*, General Electric Research Laboratories

Rapid Determination of Preferred Orientation in Magnetic Aluminum-Iron Alloys by Combination Etch Pit-Domain Pattern Technique. *P. Albert*, Westinghouse Electric Corporation

The Effect of Aging on the Time Decay of Permeability in 3 Per Cent Silicon Iron. *E. S. Anolick*, General Electric Company

Intermission

* Invited Papers.

Cedar Valley Subsection Established

Courtesy Cedar Rapids Gazette

A MEETING recognizing the establishment of the new Cedar Valley Subsection was held recently in Cedar Rapids, Iowa. Present were (*left to right*): W. G. Kaldenberg, chairman, Iowa Section; AIEE President M. S. Coover, who was the principal speaker for the occasion; and C. R. White, chairman, Cedar Valley Subsection. Other officers of the new Subsection are F. L. Hulbert, vice-president; O. W. Amador, secretary; C. K. Kruempal, Edwin Kurtz, and L. E. Plotkin, directors.

Magnetostriction of Aluminum-Iron Single Crystals in the Region of 6 to 30 Atomic Per Cent Aluminum. *R. L. Hall*, Westinghouse Electric Corporation

Supermendur, a New Rectangular Loop Magnetic Material with High Flux Density and Low Coercive Force. *H. L. B. Gould, D. H. Wenny*, Bell Telephone Laboratories

Sendust Flake—A New Magnetic Material for Low Frequency Application. *W. M. Hubbard, E. Adams, J. F. Haben*, Naval Ordnance Laboratory

Effects of Nuclear Irradiation on Magnetic Materials. *R. E. Fischell, D. I. Gordon, R. S. Sery*, U. S. Naval Ordnance Laboratory

Why Present Evaluation Methods for High Quality Magnetic Strip Materials Are Inadequate. *P. W. Neurath*, General Electric Company

2:00 p.m. Session IVb—Ferrites—Bay State Room

Presiding: V. C. Wilson

***New Magnetic Core Materials at Frequencies Up to the UHF Band.** *G. H. Jonker, H. P. J. Wijn, P. B. Braun*, Philips Research Laboratories

Domain-Wall Relaxation in Ferrites. *D. J. Epstein*, Massachusetts Institute of Technology

The Remanent State in Ferrites According to the Rotation Model. *E. H. Frei, S. Shtrikman*, The Weizmann Institute of Science

Permalloy Characteristics in Ferrites. *D. Kooi*, Lockheed Aircraft Corporation

Intermission

Susceptibility of Normal Spinels from 2°K to 300°K. *J. E. Goldman*, Ford Motor Company; *A. Arrott*, Carnegie Institute of Technology

Growth and Application of Ferrite Single Crystals. *W. G. Field, S. K. Dickinson*, Air Force Cambridge Research Center

Preparation of Ferrites by the Atomizing Burner Technique. *J. F. Wenckus, W. Z. Leavitt*, Lincoln Laboratories

Ferrite Accelerating Cavities for a 25 Billion Electron Volt Proton Synchrotron. *M. Plotkin*, Brookhaven National Laboratory

Thursday, October 18

9:00 a.m. Session V—High Frequency Phenomena—Georgian Room

Presiding: G. T. Rado

***Fundamentals of Ferromagnetic Resonance.** *N. Bloembergen*, Harvard University

Ferromagnetic Resonance in Highly Anisotropic Single Crystal Metals. *J. O. Artman*, Harvard University

Single Crystal Intrinsic Permeabilities of Ferrites. *E. G. Spencer, R. C. LeCraw, L. A. Ault, J. E. Tompkins*, The Diamond Ordnance Fuze Laboratories

Domain Structure Effects in an Anomalous Ferrimagnetic Resonance of Ferrites. *R. C. LeCraw, E. G. Spencer*, The Diamond Ordnance Fuze Laboratories

Reversible Properties of Ferromagnets. *D. M. Grimes*, University of Michigan

Intermission

***Microwave Applications of Magnetic Materials.** *D. L. Hogan*, Harvard University

A New Faraday Rotation Phenomenon and Its Application to Microwave Switching. *J. A. Weiss*, Bell Telephone Laboratories

The Production and Use of High Intensity Pulsed Magnetic Fields. *S. Foner, H. H. Kolm*, Lincoln Laboratories

The Microwave Susceptibility of Polycrystalline Ferrites in Strong D-C Fields and the Influence of Nonmagnetic Inclusions on the Microwave Susceptibility. *E. Schlomann*, Raytheon Manufacturing Company

2:00 p.m. Session VI—Switching Devices and Magnetic Amplifiers—Georgian Room

Presiding: D. R. Brown

***High Frequency Effect in Magnetic Films.** *R. L. Conger*, U. S. Naval Ordnance Laboratory

Relations between Magnetic-Core Switching-Time and the Width of Ferromagnetic Resonance Peaks. *R. P. Coleman*, Burroughs Corporation, Research Center

Magnetization Reversal in Thin Films. *D. O. Smith*, Massachusetts Institute of Technology, Lincoln Laboratories

Some Switching Properties of Square Loop Ferrites. *E. M. Gyorgy, J. L. Rogers*, Bell Telephone Laboratories

Magnetic Viscosity in 4-79 Moly Permalloy. *O. J. Van Sant*, U. S. Naval Ordnance Laboratory

Intermission

***The Ferractor.** *T. Bonn*, Sperry-Rand Univac Division

The Ferrite Bead—A New Memory Device. *D. H. Looney*, Bell Telephone Laboratories

Characteristic of a Memory Array in a Sheet of Ferrite. *R. H. Meinken*, Bell Telephone Laboratories

The Crossed-Field Magnetic Amplifier and Its Application. *E. H. Frei, D. Treves*, The Weizmann Institute of Science

Board of Directors Meeting Marks Considerable Progress

THE BOARD OF DIRECTORS of the AIEE met in New York, N. Y., on August 17, 1956. The meeting was the first to be attended by the new department chairman: administrative, admission and advancement, professional development and recognition, publications, and technical operations, as shown in the Organization Chart, *Electrical Engineering*, September 1956, pages 858–9, and four of the five chairmen were present. All 27 members of the Board of Directors were present thus having 100 per cent attendance. The attendance record of the Board members is remarkable and usually not more than one or two are absent. The vice-presidents held a meeting on the day preceding the Board of Directors' meeting, August 16.

Treasurer's Report

The treasurer reported the amounts received and expended from the general fund for the months of May, June, and July, which showed a balance of $372,831.01 as of July 31, compared with a balance of $364,050.01 for the previous year. The current year's balance was after $200,000 had been transferred to the Reserve Capital Fund the preceding month, and it is noteworthy that the balance is running ahead of the previous year, notwithstanding that last year was an exceptionally good year financially.

Finances

A comparative statement of income and expenses for May and June 1956 relative to the annual budget for the fiscal year 1956–57 was presented by the chairman of the Finance Committee. For the three-month period, current dues were coming in faster this year; 72 per cent of the budgeted amount as compared with 69 per cent of the budgeted amount for the same period the preceding year. Resignations for the first two months were only 325 compared with 553 for the same period of the previous year.

Constitution and Bylaws

Extensive revisions of the Bylaws had been necessitated by the new Plan of Organization described and illustrated in the chart appearing on pages 858–9 of *Electrical Engineering*, September 1956. The Constitution and Bylaws are being completely rewritten editorially for clarification and in order to make it easier to find items and to bring them up to date. The scopes of several committees need to be redefined to fit into the new departmental organization. New Bylaws have to be written to define the scopes of the five new departments themselves, administrative, admission and advancement, professional development and recognition, publications, and technical operations. The chairman of the Committee on Constitution and Bylaws reported that editorial revisions to the Bylaws authorized by the Board at its previous meeting have been completed and specific amendments recommended by the Committee with respect to several other Bylaws were approved.

Planning and Co-ordination

Under the new organization, the planning work of the five departments will be co-ordinated by the Planning and Co-ordination Committee, inasmuch as the chairmen of the five departments are all members of that committee. Chairman Hickernell rendered a report on some 15 assignments of the Planning and Co-ordination Committee during the administrative years 1954–55 and 1955–56. Most of these assignments had been carried through to a successful conclusion and the Board voted that the report be accepted with an expression of appreciation for a lot of good work well done.

Special Conference of Vice-Presidents

President Coover reported on the Special Conference of Vice-Presidents held the preceding day, August 16. This marked the first time that the vice-presidents now in office met in a special conference of their own. They have met in the past for a half-day conference, with the District secretaries and others attending, during the Summer General Meeting. That conference usually was attended by both the incoming and outgoing vice-presidents and District secretaries.

There are indications that this group may develop into a sixth department, or a department of District and Section organization. The special conference spent most of the day reviewing the scope of responsibilities and duties of the vice-presidents, and the time schedule for District operations. The newly completed "District Operations Guide" developed out of the original District No. 2 Manual was thoroughly reviewed and the guide is to be further revised and developed through experience by the vice-presidents themselves. Experiences were exchanged and plans were made to visit the Sections and Branches as well as the type of message to be carried by the vice-president on these visits.

Engineering Societies Center

The report of the Special Task Committee of the Founder Societies and the American Institute of Chemical Engineers (AIChE) about a location for the Engineering Societies

Center (See *Electrical Engineering*, September 1956, page 836) was approved by the Board of Directors. Specifically, the report recommended five items, as follows, on the location of the new Engineering Societies Center:

Item 1—The Engineering Societies Center be located in New York City.

Item 2—The 39th-40th Street site be continued in use as the site of the Engineering Societies Center.

If rebuilding in that area proves impracticable, a comparable site should then be sought in midtown New York.

We suggest that the Governing Boards also adopt these further recommendations for inaugurating action:

Item 3—The United Engineering Trustees, Inc. (UET), be authorized to take proper level action for expansion by the addition of the American Institute of Chemical Engineers to the incorporators when properly qualified.

Item 4—The United Engineering Trustees, Inc., be authorized to raise money and accept contributions; accept the offer of the Kelly Committee; place contributions in UET Capital Fund Assets; employ architects, engineers, and attorneys; let contracts for reconstruction of the present Engineering Societies building and/or a new building or buildings; pay all costs out of the Capital Fund Assets; and operate and maintain the new Engineering Societies Center.

Item 5—The plans for the new and enlarged Engineering Societies Center be made with ample optimism with respect to the future growth of the five societies immediately involved. These facilities should be such as to attract and hold all of the Engineering Profession, thus fostering unity and co-operation along broad lines.

The Board of Directors also approved the inclusion of the American Institute of Chemical Engineers (AIChE) in the United Engineering Trustees, Inc. (UET), under the conditions recommended by a special committee of the Board of the United Engineering Trustees, Inc.

The governing bodies of the American Society of Civil Engineers (ASCE), American Institute of Mining, Metallurgical and Petroleum Engineers (AIME), and American Society of Mechanical Engineers (ASME), had previously approved the report of the Special Task Committee of the founder societies and the AIChE.

Technical Groups in the Sections

To implement the technical group program in the Sections, a postal card survey of the membership is being made through the Sections themselves to determine the interests of the members in technical groups. Strong efforts are being made by the Sections Committee and the administration department to get the technical groups going throughout the country on a much more expanded basis than they have been operating in the past 25 years. To augment the program, the Board of Directors approved in principle the appointment of technical operations department representatives on the District Executive Committees for the purpose of stimulating and promoting the technical groups. This representation on the District Executive Committees is comparable to the present practice of having Student activities, Sections, and Membership Committee representation on the District Executive Committees.

New Members and Transfers

In accordance with the recommendations of the Board of Examiners, 7 members were elected to the grade of Fellow. Their names and citations will be reported in a subsequent issue. Other additions to the membership included 75 Members, 637 Associate Members, 53 Affiliates, 11 Student Associates, and 2 Student Affiliates.

Kettering Award

The Board of Directors voted to accept cosponsorship along with other major engineering societies in the establishment of an intersociety award to be known as the Kettering Award. As recommended, the Charles Franklin Kettering Award was to be established as of August 29, 1956, his 80th birthday. The first award to be announced at the Fall General Meeting of the AIEE will go to Mr. Kettering himself, as he joined AIEE before any of the other numerous societies of which he is a member. The award will probably be made annually.

According to the proposal, the award is sponsored by six societies, AIEE, SAE, ASME, ASCE, AIME, and AIChE. The proposal provides for a board to be appointed consisting of two members from each of the six participating societies. This board will establish rules and procedures which will be submitted to the proper branch of each society for approval as soon as practicable.

Case Book in Ethics

Institute participation in the preparation of a proposed Engineers Council for Professional Development (ECPD) "Case Book in Ethics" to be usable for teaching purposes was approved.

Additional District Student Paper Prizes

As reported at the June 29 meeting of the Board of Directors, the Members-for-Life Fund Committee has decided to provide a second and third prize for District Student Papers. The best Student Paper Prize in each of the Districts, a Certificate and $25 cash, with a trip to the Summer General Meeting, remains the same as in the past; a second prize of $25 cash, and a third prize of $15 has been added.

Technical Operations

The chairman reported that the membership of the technical operations department has been selected so that all major fields of electrical engineering would be equally represented. The representation of all major fields of electrical engineering at the top level was considered most important if AIEE is to have a uniform growth in membership from all fields of electrical engineering. Among six current projects under way were plans for honoring Nikola Tesla, a standard classification for electrical engineers, and a study of the means for and justification of establishing professional groups.

Next Meeting

Departing from a long established custom, the next meeting of the Board of Directors will be held on Friday, October 5, during the Fall General Meeting. This will free one more day in accordance with a plan recommended by the Planning and Co-ordination Committee to permit other committees and departments to hold their meetings preceding the Board meeting. The general basis of the recommendation was that Monday would be for technical committee meetings, Tuesday for technical division meetings, Wednesday for department meetings, and Thursday for meetings of the Planning and Co-ordination Committee, and the vice-presidents. In this way it was hoped that conflicts would be avoided and more time would be available

Future AIEE Meetings

AIEE-IRE-RETMA-IIT-NU-U of I National Electronics Conference*
Hotel Sherman, Chicago, Ill.
October 1–3, 1956

Fall General Meeting*
Morrison Hotel, Chicago, Ill.
October 1–5 1956

AIEE-IRE Conference of Magnetism and Magnetic Materials*
Hotel Statler, Boston, Mass.
October 16–18, 1956

AIEE-ASME Combustion Control Conference*
Norwich Inn and Country Club, Norwich, Conn.
October 19, 1956

Machine Tool Conference*
Sheraton Gibson Hotel, Cincinnati, Ohio
October 22–24, 1956

Engineers' Council for Professional Development 24th Annual Meeting
Hotel Statler, Detroit, Mich.
October 25–26, 1956

Farm Electrification Conference*
Memphis, Tenn.
October 29–31, 1956

Fall Textile Conference*
North Carolina State College, Raleigh, N. C.
November 1–2, 1956

AIEE-IRE-ISA Conference on Electronic Technology in Medicine and Biology*
Hotel McAlpin, New York, N. Y.
November 7–9, 1956

AIEE-IRE-MSU Midwest Symposium on Circuit Theory*
Michigan State University, Lansing, Mich.
December 3–4, 1956

AIEE-IRE-ACM Eastern Joint Computer Conference
Hotel New Yorker, New York, N. Y.
December 10–12, 1956
(*Final date for †TP—closed, ‡CP Syn.—colsed, CPMs—Oct. 5*)

AIEE-IRE-RETMA-ASQC Symposium on Reliability and Quality Control
Hotel Statler, Washington, D. C.
January 14–16, 1957
(*Final date for †TP—Oct. 15, ‡CP Syn.—Nov. 1, CPMs—Nov. 9*)

Winter General Meeting
Hotel Statler, New York, N. Y.
January 21–25, 1957
(*Final date for †TP—Oct. 22, ‡CP Syn.—Nov. 8, CPMs—Nov. 16*)

Southern District Meeting
Hotel Heidelberg, Jackson, Miss.
April 3–5, 1957
(*Final date for †TP—Jan. 3, §DP Syn.—Jan. 20, DPMs—Jan. 30*)

*Final date for submitting paper—closed
†TP—Transactions paper
‡CP Syn.—Conference Synopsis
CPMs—Conference Manuscript
(The CPSyn. date is 10 days before the CPMs date)
§DP Syn.—District Synopsis
DPMs—District Manuscript
(The DPSyn. date is 10 days before the DPMs date)

to pass the results of meetings on to the next level of administration.

Two formal invitations to hold the Spring meeting of the Board of Directors were received; one in connection with the District 4 meeting to be held in Jackson, Miss., April 3–5, 1957, the other to be held in connection with District 11 meeting in Dayton, May 7–9, 1957. An informal invitation from District 5 was also reported.

Conference on Electrical Techniques in Medicine and Biology Is Scheduled

THE NINTH ANNUAL Conference on Electrical Techniques in Medicine and Biology, sponsored jointly by the AIEE, the Institute of Radio Engineers, and the Instrument Society of America, will be held in New York, N. Y., November 7–9, 1956, at the Hotel McAlpin.

The purpose of this annual conference is to bring together electrical engineers and physicians, biologists, electronic engineers, radiation physicists, and radiologists, and so forth, to discuss the latest electrical and electronic techniques in biology and medicine, and to arrange symposia on current problems. In addition to members of the sponsoring societies, all persons having a professional medical, physical, or biological interest in electrical therapeutic, diagnostic, or investigative techniques are invited to attend. There will be two days of technical sessions with an evening symposium on the first day, and a one-day field trip to Brookhaven National Laboratory.

The committee for the conference includes Dr. E. D. Trout, X-ray department, General Electric Company, Milwaukee, Wis., general chairman; Dr. D. A. Holaday, director of research, Presbyterian Medical Center, New York, N. Y., program chairman; Carl Berkley, Technical Products Division, Allen B. DuMont Laboratories, Inc., Clifton, N. J., publicity chairman; and R. S. Gardner, AIEE Headquarters, arrangements.

The tentative program follows:

Wednesday, November 7

Morning Session

Panel discussion on "Instrumentation for Cardiology"

Chairman: L. B. Lusted, Clinical Center, National Institute of Health, Bethesda, Md.

A Cathode-Ray Cardiograph. *C. E. Webb*, Allen B. DuMont Laboratories, Inc.

High Voltage Condenser Discharge as a Means of Cardiac Resuscitation in Ventricular Fibrillation. *G. S. Shields*, Ridgewood, N. J.

Afternoon Session

Panel on "Methods and Standards for Measurement of Electron Beams"

Chairman: John Laughlin, Memorial Hospital, New York, N. Y.

High Velocity electron beams are being investigated for superficial therapy, food sterilization, acceleration of cracking and polymerization. Problems involved in standardization of methods and measurements of these beams will be discussed.

Evening Session

Lecture and succeeding discussion on "The Philosophy Underlying Radiation Protection," L. S. Taylor, Ph.D. Dr. Taylor is chief, Division of Atomic and Radiation Physics of the National Bureau of Standards. He is chairman of the National Committee on Radiation Protection, chairman of the International Commission on Radiation Units and Measurements, and a member of the International Commission on Radiation Protection.

Thursday, November 8

Field Trip

Brookhaven National Laboratory, Upton, Long Island, N. Y.

Emphasis will be laid during this trip on radiation protection problems.

Friday, November 9

Morning Session

Panel Discussion on "Design of Instruments for Research in Artificial Respiration"

Present-day mechanical respirators are relatively inflexible compared with the changing respiratory needs of the patient, and indifferent to the varying physiological requirements of a wide range of disorders. Further development in this field awaits definition of specifications based on a better understanding of the physics of respiration and its reflection on the circulation.

Afternoon Session

Session on "Instrumentation in Medicine and Biology"

Artificial Respiration Control. *L. H. Montgomery*, Vanderbilt University

A New Type Electroencephalograph Wave Analyzer. *R. J. Levine*, Edin Corporation

Machine Tool Subcommittee to Sponsor Conference in Cincinnati

THE 1956 AIEE Conference on Machine Tools will be held in Cincinnati, Ohio, October 22–24, at the Hotel Sheraton-Gibson. The conference is sponsored by the Machine Tool Subcommittee of AIEE.

The conference program is centered around Numerical Control of Machine Tools and many aspects of the progress in this field will be presented. Ample time has been allotted for "question and answer" periods, and copies of the technical papers will be available. In addition to numerical control, papers on other subjects will be included.

Inspection trips have been planned which include: Allis-Chalmers Manufacturing Company, Cincinnati Milling Machine Company, and the G. A. Gray Company.

It is felt that the conference will have a wide appeal to those people concerned with any phase of the Machine Tool Industry, users, suppliers, and manufacturers.

Anyone interested in attending this conference can write to: W. H. Davis, Allis-Chalmers Manufacturing Company, 4453—34th Street, Cincinnati 9, Ohio. Registration fee is $3 for AIEE members, $5 for nonmembers; checks payable to 1956 AIEE Conference on Machine Tools.

The tentative program is as follows:

Monday, October 22

8:30 a.m. Morning Session

Registration

Cincinnati Section Welcome: Don Michael, chairman

"50 Years of Co-operative Preparation of Engineers for Industry"

"University Viewpoint": H. K. Justice, dean of engineering, University of Cincinnati

"The Machine Tool Industry Viewpoint": L. K. Polk, president, National Machine Tool Builders Association

1:30 p.m. Afternoon Session

Panel Discussion on New Developments in Static Control Elements: F. L. Fisher, Allen-Bradley Company; Jack Sheets, General Electric Company; Gerald Secor, Cutler-Hammer Corporation; O. M. Bundy, Clark Controller Company; P. G. Hanna, Westinghouse Electric Company

Wiring Automatic Machinery with Maintenance as a Factor. *R. N. Johnson*, W. F. and John Barnes Company

Latest Revision of Machine Tool Electrical Standards. *E. J. Loeffler*, chairman, NMTBA Electrical standards committee

7:00 p.m. Banquet

Speaker: Dr. Walter Langsam, president, University of Cincinnati

Tuesday, October 23

9:00 a.m. Morning Session

Fundamentals of Numerical Control. *Ralph Schuman*, Warner and Swasey Company

Computer Elements Available for Machine Tool Use. *G. F. Baldwin*, General Electric Company; *H. Tholstrup* Commercial Controls Corporation

Potential of Numerical Control in the Aircraft Industry. *K. G. Wood*, Boeing Airplane Company

Programming for Giddings and Lewis Numericord System. *Ken Jensen*, Giddings and Lewis Machine Tool Company

12:30 p.m. Informal Luncheon

2:00 p.m. Afternoon Session

Precise Positioning with Numerical Control. *E. E. Kirkham*, Pratt and Whitney

The Numill, A Numerically Controlled Machine for Two Dimensional Parts. *J. L. Bower*, North American Aviation Company

Digimatic, The E.C.S. Contouring System for Machine Tools. *Jack Rosenberg*, Electronic Control Systems, Inc.

Wednesday, October 24

9:00 a.m. Morning Session

Bendix Numerical Control System. *R. C. Sims*, Bendix Aviation Corporation

The Cincinnati Numerical Control System. *H. M. Fuldner, J. W. Wilson*, Cincinnati Milling Machine Company

Where Do We Go From Here? *Tell Berna*, general manager, National Machine Tool Builders Association

1:00 p.m. Inspection Trips

Allis-Chalmers Manufacturing Company
G. A. Gray Company
Cincinnati Milling Machine Company

New York Section Educational Committee to Sponsor Study Groups

The Educational Committee, Power and Industrial Division, New York Section, has announced the Special Study Groups listed below which it will sponsor as part of the Fall 1956 educational program. This phase of the educational program is designed to present up-to-date information and instruction in engineering and related subjects which are of current interest to engineers and others in allied fields. All study groups are open to the public.

Registration for a study group may be made at the opening session or by application to N. A. Bleshman, Room 7310, Public Service Electric and Gas Company, 80 Park Place, Newark, N. J.

Management and the Engineer—A series of conferences led by outstanding men from industry management and academic institutions. The discussions are designed to assist engineers who look forward to a future in management. Tuesdays, 6:30 to 8:30 p.m. Starting September 25, at Westinghouse Auditorium, 40 Wall St., New York, N. Y.

Digital and Analogue Computer Engineering—Starting with an introduction to computers, continuing through operation of various digital and analogue computers to their use in practical engineering problems, this study group will emphasize applications and will include analogue to digital conversion. Mondays, 6:30 to 8:30 p.m. Starting October 1, at Remington Rand Auditorium, 315 Fourth Ave., New York, N. Y.

New Concepts of Control Systems—Theory and application of static relaying and feedback control systems. The study group will include theory of logic elements as well as the tools to apply them to control systems. Wednesdays, 6:30 to 8:30 p.m. Starting October 3, at Westinghouse Auditorium, 40 Wall St., New York, N. Y.

Transformer and Switchgear Application—Some basic considerations in the problems of distribution systems and their protection; a discussion of switchgear and transformer design as applied to these considerations; and the practical aspects of the selection of switchgear and transformers. Thursdays, 6:30 to 8:30 p.m. Starting October 4, at Ebasco Auditorium, Room 240, 2 Rector St., New York, N. Y.

Second Midwest Symposium on Circuit Theory Is Scheduled

The Electric Circuit Subcommittee of the Committee on Basic Sciences is joining the Institute of Radio Engineers (IRE) Professional Group on Circuit Theory and the electrical engineering department of Michigan State University in sponsoring the Second Midwest Symposium on Circuit Theory to be held December 3-4, 1956 at Michigan State University.

The Symposium will consist of four sessions, as follows: Topology and Circuit Theory, Systems Analysis and Synthesis, Circuit Theory and Applications, and The Place of Circuit Theory in Education. The applications session will deal with such topics as feedback, transistor circuits, and electromechanical systems. The session on education will conclude with a panel discussion, whereas the other sessions will consist of formal papers by nationally known authorities in Circuit Theory.

A talk, entitled "Engineering Education for the Future," will be given by Dr. J. D. Ryder at a banquet on Monday evening, December 3. A large number of the papers on the program will be given by prominent engineers in the educational field.

Dr. Brooks Commended for Service to Science of Measurement

At a recent meeting of the former Instruments and Measurements (I and M) Committee of the Science and Electronics Division, the following resolution on Dr. H. B. Brooks (F '31) of the National Bureau of Standards was unanimously and enthusiastically adopted.

WHEREAS, the present meeting of the I and M Committee of the AIEE and its rise to the status of a full Division coincides with the 50th anniversary of the organization by Dr. H. B. Brooks of an Electrical Instruments Section at the National Bureau of Standards (NBS), and

WHEREAS, the Electrical Instruments Section of NBS has been continuously represented on this Committee since its organization either by Dr. Brooks or by one of his associates, and

WHEREAS, the contributions of this group to the art of measurement and to the field of Instrument Standardization have been accomplished under the leadership and inspiration of Dr. Brooks,

THEREFORE, be it resolved that this Committee extend to Dr. Brooks its best wishes, and its thanks for his many outstanding achievements in the field of electrical measurements, and its congratulations on the completion of a half century devoted to the advancement of the art and science of measurement.

H. B. Brooks

Farm Electrification Conference Will Be Held in Memphis, Tenn.

The second AIEE Farm Electrification Conference, sponsored by the Farm Electrification Subcommittee of the Domestic and Commercial Applications Committee, will be held in Memphis, Tenn., October 29–31, 1956, at the Hotel Peabody.

An inspection trip has been planned for Tuesday afternoon, October 30, which will include visits to highly electrified farms where visitors will see electricity used for automatic poultry production, irrigation, crop drying, and crop processing on a large acreage farm.

The tentative technical program for the conference follows.

Monday, October 29

9:00–10:00 a.m. Registration—Hotel Peabody

Morning Session

Chairman: J. H. Oliver, General Electric Company

10:15 a.m. Welcome to Memphis, George Davis, Arkansas Power and Light Company, chairman of AIEE Memphis, Tenn., Section

The Program for the Meeting, J. H. Oliver, program chairman

The Role of Light and Radiation in Agriculture. *J. P. Dickman*, General Electric Company

Educational Techniques for the Promotion of Electricity on the Farm. *William Walker*, Tennessee Valley Authority

Afternoon Session

Chairman: T. H. Kline, Newark Stove Company

2:00 p.m. **Grounding in Rural Structures.** *O. K. Coleman*, Duncan Electric Company

New Materials in Farm Wiring. *H. H. Watson*, General Electric Company

Intermission

A Report on the National Farm Wiring Conference. *Russell Gingles*, manager, Farm Electrification Bureau, NEMA

Farm Safety. *C. L. Smith*, secretary, International Association of Electric Inspectors; *T. P. Branch*, wiring advisor, Rural Electrification Administration; *Frank Hanlin*, service engineer, Underwriters Laboratory; *Glen Rotvell*, Fire Underwriters Inspection Bureau; *H. H. Watson*, chairman, NEMA, Farm and Rural Market Development Committee

Tuesday, October 30

Morning Session

Chairman: W. W. Warner, General Electric Company

9:00 a.m. **A New Repulsion Capacitor Motor.** *S. S. Brown*, Brown-Brockmeyer Company

The Design of Electric Motors for Submerged Operation in Wells. *E. J. Schaefer*, Franklin Electric Company

The Need for Larger Electric Motors on the Farm. *Nolan Mitchell*, Aerovent Fan and Equipment, Inc.

Intermission

Selection and Application of Electrical Equipment for Irrigation Pumping. *C. Young*, Irby Seay Company

Small Irrigation Pumping Loads. *H. O. Roberts*, Central Power and Light Company

Conference Papers Open for Discussion

Conference papers listed below have been accepted for AIEE *Transactions* and are now open for written discussion until October 26. Duplicate double-spaced typewritten copies of each discussion should be sent to Edward C. Day, Assistant Secretary for Technical Papers, American Institute of Electrical Engineers, 33 West 39th Street, New York 18, N. Y., on or before October 26.

56-652 Protecting A-C Motors With Low-Voltage Air Circuit Breaker Series Trip. *F. P. Brightman, P. J. Reifschneider, R. R. McGee*

56-271 Color-Television-System Performance Requirements. *Ralph Kennedy*

56-653 The Communication Engineer's Needs in Information Theory. *W. T. Rea*

Preprints may be purchased at 40¢ each to members, 80¢ each to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 West 39th Street, New York 18, N. Y.

J. H. Van Vleck, dean of engineering, Harvard University, will preside at the dinner to be held at 6:30 p.m. After greetings are offered by C. W. Jewett, lieutenant governor of Connecticut, E. G. Bailey, past president of ASME, will speak on "Fundamentals of Combustion Control."

According to the tentative program, the technical session, which will begin at 8:15 p.m., will have as cochairmen, P. V. Stevens, Montaup Electric Company, and W. H. Weaver, University of Massachusetts. During Part I of the session, Application of Combustion Controls, the speaker will be S. C. Leland, Stone and Webster Engineering Corporation.

Part II will consist of a Symposium on Operating Experience with Combustion Controls. The speakers will be D. I. Manter, Public Service Company of New Hampshire; K. C. Sokolosky, New England Power Company; N. E. Cheney, Boston Edison Company; A. L. Schindler, Boston Edison Company; G. H. Gowdy, New England Gas and Electric System; W. D. Bissell, Montaup Electric Company; C. V. Fry, New Bedford Gas and Edison Company; J. R. Haskin, Western Massachusetts Electric Company; R. A. Evans, The Hartford Electric Light Company; G. J. Lanzolatta, The Connecticut Light and Power Company; R. E. Higgins, United Illuminating Company; B. A. Bittner, S. D. Warren Company; C. K. Stickney, Scovill Manufacturing Company; and J. J. Vozella, Oxford Paper Company.

AIEE and IRE to Sponsor Creative Engineering Symposium

The Philadelphia Sections of AIEE and Institute of Radio Engineers (IRE) will jointly sponsor a Creative Engineering Symposium consisting of six lectures. The first five lectures will be on consecutive Thursday evenings, October 11, 1956 through November 8, 1956 and the sixth lecture will be on Tuesday, November 13, 1956. All lectures will be held in the University Museum Auditorium, 33rd and Spruce Sts.

This will be a thought-provoking series of talks designed to stimulate engineering imagination and thinking. Outstanding speakers in the fields of research, design, product development, psychology, promotion, and advertising are included on the program. Among these speakers will be K. E. Brigham, Dr. S. O. English, D. G. Fink, Dr. A. N. Goldsmith, G. F. Metcalf, Dr. J. A. Morton, J. J. Newman, C. M. Sinnett, Dr. W. F. G. Swann, H. J. Woll, and William Wills.

Advance registration for professional society members is $3 and for nonmembers is $4. There will be a $1 additional fee for all registrations received after October 4, 1956. Single sessions will be at a rate of $1.50 each. Checks should be made payable to F. M. Jones, Treasurer, Creative Engineering Symposium. Advance registration should be forwarded to: AIEE-IRE Creative Engineering Symposium c/o Earl Masterson, Remington Rand Univac, P. O. Box 5616, Philadelphia 29, Pa.

AIEE Mexico Section Holds Dinner for ASME

The Mexico Section of the AIEE was host recently to the local section of The American Society of Mechanical Engineers (ASME), and to the wives of all members at a dinner in the American Club, Mexico City, Mexico.

An unusually large gathering of about 100 members and guests heard Emilio Leonard, former chief engineer to the Mexican Light and Power Company, speak on "The Correlation of Mayan Dates."

The correlation of the Mayan and Christian calendars is still the subject of a great deal of controversy, due to the fact that many previous attempts at correlation have been made, based on historical records.

Mr. Leonard is endeavoring to calculate the exact dates of the eclipses registered on Mayan monuments, and with the help of this information, to establish an exact correlation on a mathematical basis.

This talk will undoubtedly rank amongst the most interesting ones in the annals of the learned societies of Mexico.

24th Annual ECPD Meeting Planned for October

The 24th Annual Meeting of Engineers' Council for Professional Development (EPCD) will be held October 25–26, 1956, in Detroit, Mich.

The meetings, through the courtesy of the Engineering Society of Detroit, will be held at their headquarters. The two luncheons also will be held there.

Headquarters will be the Statler Hotel, where the annual dinner will take place.

Those interested should be sure to make hotel reservations and to return pre-registration cards regarding attendance, guests, reservations for the annual dinner and luncheons, etc., as soon as possible.

Address all inquiries regarding arrangements and tickets for programs to: ECPD Annual Meeting Committee, Engineering Society of Detroit, 100 Farnsworth Ave., Detroit 2, Mich.

The tentative program for the meeting is as follows:

Thursday, October 25

9:00 a.m. Registration

Delivery of Tickets for Program Events—Engineering Society of Detroit (ESD) Lobby

9:30 a.m. "Welcome to Detroit"

The Honorable A. E. Cobo, mayor of Detroit Introduced by Earnest Boyce, president, ESD
Auditorium, ESD

10:00 a.m. The First Five Years of Professional Development

Presiding: G. A. Porter, chairman, Sponsoring Group, Detroit Industry Training Committee; vice-president, Detroit Edison Company

Addresses by: J. J. Cronin, vice-president, General Motors Corporation; C. J. Freund, dean of Engineering, University of Detroit; A. C. Monteith, vice-president, Westinghouse Electric Corporation

12:00 noon Luncheon (Ladies included)—Banquet Hall, ESD

Presiding: Thorndike Saville, president, ECPD

Speaker: Dr. Kenneth McFarland, educational consultant for General Motors Corporation

1:45 p.m. Panel Discussion

Points of the First Five Years of Professional Development Program and Their Application in Detroit:

Panel on Orientation, Training, and Appraisal—Rooms E, F, and G, ESD

Presiding: M. W. Johnson, general supervisor, Personnel Development, Engineering Division, Chrysler Corporation

Panel on Continued Education and Selected Reading—Junior Society Room, ESD

Presiding: K. A. Meade, director, Educational Relations Section, General Motors Corporation

Panel on Professional Identification and Integration into the Community—Rooms C and D, ESD

Presiding: H. P. Seelye, engineering consultant, Detroit Edison Company

3:15 p.m. Summary of Panel Discussions—Auditorium

Presiding: E. L. Yates, chairman, Detroit Industry Training Committee

3:30 p.m. Administrative Session—ECPD

For members of Council and chairmen of committees—Rooms C and D, ESD

5:45 p.m. Reception—Cocktails (Ladies included)—Bagley Room, Hotel Statler

Host: Detroit Industry Training Committee

6:30 p.m. ECPD Annual Dinner (Ladies included)—Wayne Room, Hotel Statler

Presiding: Thorndike Saville, president

Recognition of past presidents, presidents of participating Societies, representatives of Local Engineering Organizations

Presentation of Annual Report: Thorndike Saville, president

Address: J. H. Foote, president, Commonwealth Associates, Jackson, Mich.

Friday, October 26

9:00 a.m. Registration—ESD Lobby

9:00 a.m. Executive Session

Members of Council and chairmen of Education and Accreditation Committee—Rooms C and D, ESD

9:00 a.m. Opening Meetings of Committees

Guidance—Conference Rooms E and F, ESD

Student Development—Conference Room A, ESD

Training—Conference Room G, ESD

Recognition—Conference Room B, ESD

Ethics—Junior Society Room, ESD

12:00 noon Luncheon—ESD Banquet Hall (Event G)

Presiding: Thorndike Saville, president

Speaker: N. W. Dougherty, dean emeritus, College of Engineering, University of Tennessee

1:30 p.m. Open Committee Meetings

2:30 p.m. Open Council Meeting—Auditorium, ESD

Presiding: Thorndike Saville, president

Presentation of reports as printed in the preprint of the 24th Annual Report

For the Standing and Special Committees:

Guidance—K. F. Treschow, chairman, secretary, Engineers' Society of Western Pennsylvania

Education and Accreditation—H. L. Hazen, chairman, dean, The Graduate School, Massachusetts Institute of Technology

Student Development—N. W. Dougherty, chairman, dean emeritus, College of Engineering, University of Tennessee

Training—E. L. Yates, chairman, personnel staff, General Motors Corporation, Detroit, Mich.

Recognition—G. H. O'Sullivan, chairman, electrical engineer, J. G. White Engineering Corporation, New York, N. Y.

Ethics—C. J. Freund, chairman, dean of Engineering, University of Detroit

Information—W. E. Jessup, chairman, editor, *Civil Engineering*, American Society of Civil Engineers, New York, N. Y.

Practice of Engineers (ECPD/EJC)—Charles Molineaux, chairman, Arthur A. Johnson Corporation, New York, N. Y.

Engineering Profession Survey (ECPD/EJC)—M. D. Hooven, chairman, electrical engineer, electrical engineering department, Public Service Electric and Gas Company, Newark, N. J.

Reports from Participating Societies

5:00 p.m. Adjournment of 24th Annual Meeting

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

EJC To Co-ordinate Nuclear Engineering and Science Congress

The Second Engineers Joint Council (EJC) Nuclear Engineering and Science Congress and accompanying Atomic Exposition will be held early in 1957 in Philadelphia, Pa. Like the first Congress, which was held in December 1955 in Cleveland, Ohio, the 1957 event will be co-ordinated by EJC. Both the technical sessions and the over-all Congress meetings, as well as the Exposition, will be held in the Convention Hall, March 11–15, 1957.

Nineteen major engineering and scientific societies already have indicated their participation in the Congress. An even larger group of engineers and scientists from industry, business, education, and Government, than the nearly 3,000 who attended the Cleveland meeting, are expected in Philadelphia. It is also expected that the Atomic Exposition, which will display the latest developments in the application of nuclear energy will draw a greater audience than the 13,000 who saw the Cleveland exhibits. There will be a greater number of exhibitors in the Exposition, reflecting the additional enterprise in nuclear energy and allied fields, which will have come into being in the 14 months since the last Congress.

Dr. W. G. Whitman, who was chairman of the United States delegation to the 1955 Geneva Conference on Atomic Energy and head of Chemical Engineering at Massachusetts Institute of Technology, has been named chairman of the General Committee for the Congress. Chairman of the Program Committee is B. R. Prentice, of the General Electric Company, Schenectady, N. Y. and a member of the EJC Panel on Atomic Energy.

The Atomic Exposition will be sponsored by the American Institute of Chemical Engineers and will be under the management of Denham and Company, Detroit, Mich.

Societies which have indicated their intention to participate in the Second Nuclear Engineering and Science Congress include the constituent societies of EJC, which are: AIEE; American Society of Civil Engineers; American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc.; The American Society of Mechanical Engineers; American Water Works Association; The Society of Naval Architects and Marine Engineers; American Society for Engineering Education; The American Society of Refrigerating Engineers; American Institute of Chemical Engineers; and the associate societies of EJC, which are: American Society of Agricultural Engineers, and The American Institute of Industrial Engineers.

Other societies that have indicated their participation in the Congress are: American Chemical Society, Institute of Radio Engineers, American Geological Institute, American Society for Metals, Atomic Industrial Forum, Society of Automotive Engineers, American Society for Testing Materials, and Federation of Sewage and Industrial Wastes Associations.

AIEE Members Take Part in Labor Day Radio Broadcast

Twenty one of the nation's leaders in labor, industry, science, and education, including five AIEE members took part in a 15-hour Labor Day broadcast on WOR and the Mutual Broadcasting System Monday, September 3. In their talks they defined the significance of Labor Day and told about the contributions of engineers and others to the progress of the Twentieth Century.

The broadcast celebration, known as "Freedom's Forge," began at 9 a.m. and continued at intervals until midnight, with an hour-long documentary drama, "Freedom's Forge," starring Lawrence Tibbet at 4 p.m.

The electrical engineers whose talks were heard were M. S. Coover, administrative assistant, engineering department, Iowa State College, and president of AIEE; M. D. Hooven, electrical engineer, Public Service Electric and Gas Company, Newark, N. J., and past president of AIEE; Gordon Thayer, chief engineer, American Telephone and Telegraph Company; F. S. Black, editor and publisher, *Electrical World*, and chairman of the AIEE Public Relations Committee; and G. T. Minasian, director of community relations, Consolidated Edison Company, and former AIEE Public Relations chairman.

The five told about some of the electrical wonders of the age. Mr. Coover and Mr. Hooven discussed radio in a 15-minute evening program; Mr. Thayer told about telephone advances; Mr. Minasian spoke about light; and Mr. Black told of the contributions of motors.

R. A. Heising Receives Founders Award from IRE

Dr. R. A. Heising (F '39, Member for Life), radio pioneer and consulting engineer, has been named recipient of the Founders Award by the Institute of Radio Engineers (IRE).

The award, which is given only on special occasions to an outstanding leader in the radio industry, was bestowed on Dr. Heising ". . . for his leadership in Institute affairs, for his contributions to the establishment of the permanent IRE Headquarters, and for originating the Professional Group system." Presentation of this award will be made at the annual IRE banquet to be held at the Waldorf-Astoria Hotel, New York, N.Y., March 20, 1957, during the IRE national convention.

Dr. Heising was associated with the Western Electric Company and Bell Telephone Laboratories from 1914 until his retirement in 1953. He played a major role in the original development of transoceanic and ship-to-shore radio telephone systems for the Bell System and contributed many firsts in this field. He conducted and supervised much research work on ultrashort waves,

electronics, and piezoelectric crystal devices that underlie modern radio.

The developer of many important inventions, he is best known for designing several widely used modulation systems, in particular the constant-current or Heising modulation system. He has over 100 United States patents, including the patent on the class C amplifier, and has published numerous technical papers in engineering journals.

Since 1953, Dr. Heising has been engaged in independent consulting and patent work.

He is a Fellow and Life Member of the Institute of Radio Engineers and a Fellow of the American Physical Society. He received the IRE Morris Liebmann Memorial Prize in 1921 and the Modern Pioneer Award from the National Association of Manufacturers in 1940.

Dr. Heising served as president of IRE in 1939, treasurer from 1943 to 1945, and was a member of its Board of Directors for 17 years.

Chicago ESPS Reports on Recent Employment Study

The Chicago, Ill., Office of the Engineering Societies Personnel Service, Inc. (ESPS), has made a study recently of the registrations and job opportunities in their current or active files. This resulted in some interesting figures which, it is believed, will be of interest to the engineering and scientific professions.

Since the first of the year, the Chicago office of ESPS has averaged better than $2^1/_2$ job opportunities for every man registered. This indicates that now is the ideal time to register with the Chicago office, for anyone interested in seeking new or better employment. By the time this article is published, the Chicago office will have converted to 100 per cent Employer Pays Fees.

Taking various statistical facts into consideration, the Chicago office of ESPS requested the National Board of Directors for permission to convert to the 100 per cent Employer Pays Fees Plan. The approval was received and ESPS converted to the plan as fast as possible.

Additional Conference Papers Are Now Available

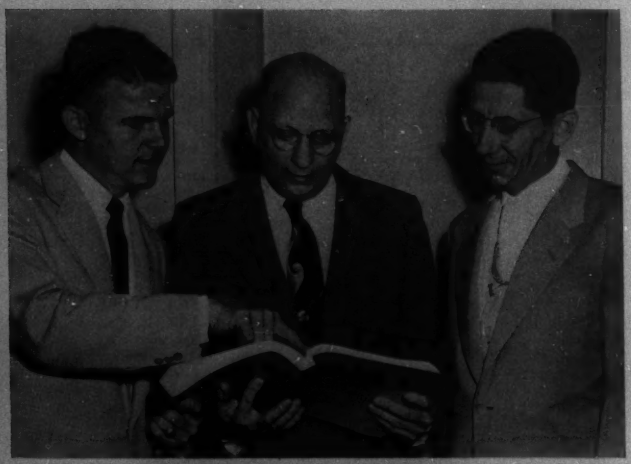
The following is the list of conference papers presented at the 1956 Summer and Pacific General Meeting which were not numbered at the time of the meeting. They have now been numbered and are available to members for 40¢, and to nonmembers for 80¢. Send order and remittance to: AIEE Order Department, 33 West 39th Street, New York 18, N. Y.

Summer and Pacific General Meeting
June 25–29, 1956, San Francisco, Calif.

CP56-816 A Transistorized Distance Relay. *F. R. Bergseth*

807 Tests and Operating Experience with Carrier Transfer Trip Relaying for Line Protection. *A. W. Adams*

New Georgia Section Officers



RECENTLY ELECTED OFFICERS of the Georgia Section of AIEE are (*left to right*) J. F. Willett, vice-chairman headquarters representative, electric utility department, Westinghouse Electric Corporation, Atlanta, Ga.; T. J. Allen, chairman, superintendent of transmission, Georgia Power Company, Atlanta, Ga.; and W. J. McKune, secretary, professor of electrical engineering, Georgia Institute of Technology, Atlanta, Ga.

Bimonthly Publications

The bimonthly publications, *Communication and Electronics, Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

899 Precise Determination of the Watt-Hour. *L. E. Jonstor, J. J. Hall*

818 What Use Is Delta Modulation to the Transmission Engineer? *F. K. Bowers*

873 Ethics for Organizations. *C. A. Powel*

898 The Additional Service Life of Poles Obtained by Supplementary Treatment in the Field. *J. W. Andrews, C. W. Lasch*

876 Recent Trends in Pump Motor Design. *W. B. Rice*

900 The Inductronic Double Bridge. *J. H. Miller*

844 Error Checking with Particular Reference to Telegraph Systems. *R. M. Gryb*

836 The Influence of Practical Considerations on the Use of Electric Heating for Homes. *S. L. Forsyth*

813 Favorable Economics of Resistance Heating. *J. C. Beckett*

812 The Effect of Space Heating on Utility Systems on the Pacific Coast. *C. E. Baugh*

837 Rapid Transit Expands in Chicago. *S. D. Forsythe*

827 Electrical Hazards in Distribution Systems. *E. E. Carleton*

848 Modern Brakes for Modern Rapid Transit Cars. *C. M. Hines*

892 First Year's Operating Experience with New Control Equipment on 100 New York City Subway Cars. *G. W. Weber*

841 Computers in Business and Industrial Control Problems. *R. M. Grabbe, Harry Larson*

884 The Power-Distribution System of an Integrated Steel Plant. *Donald Stewart, Jr.*

829 Operating Experiences with the Mechanical Rectifier. *Thomas Costsona*

855 A Description of the Electrical Installation of the Anaconda Aluminum Plant at Columbia Falls, Mont. *H. W. Kanzler*

817 Teaching Magnetic Amplifier Circuits. *H. C. Bourne, R. M. Saunders*

852 Management Development in the Communications Field. *Glen Ireland*

815 How an Engineering Education Fits an Individual for a Management Position. *G. S. C. Benson*

895 A Silicon Diode Voltage Reference Unit. *W. H. Woodworth, A. Pearson*

850 Evaluation of Materials for Reducing Vibration Effects on Toroidal Cores. *W. F. Horton*

889 Remote Control of Directional and High Power Standard Broadcast Stations. *A. P. Walker*

860 Ad-da-verters 1—Specifications for Analogue-Digital-Analogue Converting Equipment for Stimulation Use. *R. M. Lager*

809 Design and Construction of Ad-da-verter System. *Eli Anfenger*

842 Ad-da-verters IV—Combined Analogue-Digital Computer Operation. *J. L. Greenstein*

885 Computer Applications in the Metal Working Industries. *L. F. Stringer*

874 Automatic Control for Continuous Processing Lines. *F. L. Reed*

839 Automatic Operation of Interconnected Areas. *A. F. Glimn, L. K. Kirchmayer, H. H. Chamberlain*

880 VHF Propagation Over Rough Terrain. *A. G. Sparling*

823 Cathodic Protection for Steel Retention Tanks Containing Reactor Coolant Water. *C. S. Bucholz*

857 Minimizing the Fifth and Seventh Harmonics from A-C Distribution System. *W. R. Kiltz*

833 Petroleum Refinery Electrical Power Systems. *G. R. Dunbar*

897 Power for Delaware Flying A Refinery. *W. C. Cauthen*

875 Modern Computer Analysis for the Design of Steel Mill Control Systems. *J. E. Reider, P. Spergel*

828 Adaptation of the Chromatron Tube for Military Applications. *D. R. Cone*

831 The Germanium Rectifier Is Growing Up. *R. M. Crenshaw*

890 Emergency Use of Microwave Radio in Northern California. *M. W. Walther, C. S. Watkins*

824 TACAN. *H. Busignies*

865 Jointing Aluminum Sheathed Power Cable. *E. J. Merrell, R. A. Rustbach*

846 Application of "3-5" Compounds to Devices. *H. W. Henkels*

888 Progress in the Development and Design of the Dresden Nuclear Power Plant. *C. H. Robbins*

871 Control and Instrumentation of the Dresden Nuclear Power Plant. *E. P. Peabody*

878 Description of the Pressurizer Water Reactor (PWR) Power Plant at Shippingport, Pa. (a) Nuclear Power Generation. *J. W. Simpson, M. Shaw;* (b) Turbine Generator Plant. *R. B. Donworth, W. J. Lyman;* (c) Core Design. *I. H. Mandil, N. J. Palladino*

808 A Development Fast Neutron Breeder Reactor. *W. N. McDaniel, A. Amorosi, A. P. Donnell, H. A. Wagner*

861 Single-Line Diagrams—Hydro Stations of Aluminum Company of Canada, Ltd. *J. T. Madill, W. O. Codrington*

845 Some Relationships between Analogue and Digital Computers. *R. Hamming*

883 General Purpose Electronic Areas for Nuclear Research. *A. J. Stripeika*

854 The Westinghouse Testing Reactor. *A. R. Jones*

894 The Belgian Thermal Reactor. *R. L. Witzke, G. Tavernier*

810 Protection and Application of Series Capacitors Used with Distribution Transformers. *G. G. Auer, L. W. Robbins, N. M. Neagle*

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Communication Division

Committee on Communication Theory (L. G. Abraham, *Chairman;* R. K. Hellmann, *Vice-Chairman;* W. R. Bennett, *Secretary*). This relatively new Committee has sponsored sessions at Chicago, Ill., New York, N. Y., and San Francisco, Calif., on various aspects of communication theory and will sponsor another at Chicago, Ill., in October. The primary purpose of the Committee is to interpret communication theory to the general communications engineer rather than to appeal mainly to highly theoretical people. The response, as indicated by sessions' attendance, has been gratifying and the Committee expects to continue along this line. Any suggestions from others would be appreciated.

General Applications Division

Committee on Marine Transportation (J. E. Jones, *Chairman;* J. D. Shuster, *Vice-Chairman;* W. N. Zippler, *Secretary*). This Committee met on May 11, 1956, at the Engineering Societies Building in New York, N. Y. The meeting was one of two which are held annually for discussion of matters related to AIEE No. 45, "Recommended Practice for Electrical Installations on Shipboard."

The principal responsibility of the Committee is the AIEE No. 45 publication. It is revised at intervals of approximately three years. In the intervening periods, the main Committee and the various subcommittees engage in studies of proposed revisions brought about by changes in practice and/or development of new materials and equipments. The main Committee acts on all final recommendations and those that are approved are included in the subsequent reissue of the AIEE No. 45 publication.

The Marine Transportation Committee also has the responsibility of representing the United States on Technical Committee No. 18 of the International Electro-Technical Commission (IEC). In connection with this responsibility, the Subcommittee on International Standardization presented to the main Committee a report on the meeting of IEC Technical Committee (TC) No. 18 held in The Hague, Netherlands, December 6–9, 1955. The meeting was attended by 68 representatives from 13 different nations. It was reported that TC No. 18 presently is publishing the first edition of "International Recommendations Concerning Shipboard Electrical Practices." The next meeting of TC No. 18 will be held in Italy in May 1957 and will be attended by members of the Committee on Marine Transportation.

The next regular meeting of the AIEE Marine Transportation Committee is scheduled for October 1956.

Science and Electronics Division

Committee on Computing Devices (E. L. Harder, *Chairman;* D. C. Ross, *Vice-Chairman;* S. H. Dodd, Jr., *Secretary*). The Committee on Computing Devices is sponsoring several sessions at the Fall General Meeting in Chicago, Ill., including sessions sponsored jointly with other committees. Growing interest in specific applications of computers is being reflected in joint sessions in co-operation with other committees which encounter applications for computers. Four full days of sessions are being planned for the Winter General Meeting, to include data processing equipments, computer comparisons, automation, simulation, and methods of analysis. The West Coast Subcommittee of the Committee on Computing Devices was augmented at the Summer Meeting, with D. McCann as its chairman. This committee provides direct contact with the growing computer activities on the West Coast and will co-operate with sections there to provide programs in the computer field. The West Coast Subcommittee has also taken responsibility for AIEE representation in the Western Joint Computer Conference. H. F. Mitchell, Jr. and P. L. Morton are the delegated representatives for this.

AIEE FELLOWS ELECTED

Board of Directors Meeting, June 29, 1956

Constantine William Bary (AM '25, M '43), economic analysis engineer, Philadelphia Electric Company, Philadelphia, Pa., has been transferred to the grade of Fellow in the AIEE "...for his work in engineering research and development of methods for dealing with present and future economics of electric utility service." Mr. Bary was born in St. Petersburg, Russia, December 26, 1903. He received a bachelor of science degree in electrical engineering from Massachusetts Institute of Technology in 1927. From 1922 through 1926, he did field construction work, drafting and design work, and inspecting and testing work for the Philadelphia Electric Company. In 1927, he became technical assistant to the vice-president in charge of engineering until he was promoted to engineer, rate and standard practice department in 1932. He held that position until 1938 when he was appointed chairman of the load research committee of the Association of Edison Illuminating Companies, and made a rate research engineer. The former position is still held by Mr. Bary, and the latter he held until 1955. During 1941–42, he became consultant for the Office of Production Management of the War Production Board. Then, from 1942–45, he was chief, Power Requirements and Forecasts, War Production Board. As chairman of the Committee on Public Utility Reports of the Advisory Council on Federal Reports to the Bureau of the Budget, he served the nation from 1945–49. He is still associated with several departments of the Government in a consulting capacity. From 1955 to the present time, he has been economic analysis engineer for the Philadelphia Electric Company. He holds membership in the MIT Club of Philadelphia, The Engineers Club of Philadelphia, and the Franklin Institute. Mr. Bary has served on the AIEE Committee on Domestic and Commercial Applications (1952–56).

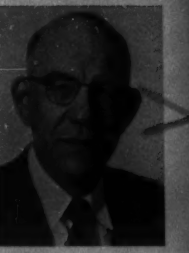
Reginald Ralph Benedict (AM '27, M '41), professor of electrical engineering, University of Wisconsin, Madison, Wis., has been transferred to the grade of Fellow in the AIEE "...for his teaching and contributions to the engineering literature in the field of industrial electronics." Prof. Benedict was born in Medford, Wis., October 1, 1904. He attended the University of Wisconsin, receiving

C. W. Bury

Courtesy Brookfield

R. R. Benedict

C. T. Button



L. K. Del'Homme

a bachelor of science degree in electrical engineering in 1925, and a master's degree in 1926. He joined the faculty of the University of Wisconsin in 1928 as an instructor in electrical engineering. He became assistant professor in 1936, associate professor in 1943, and professor in 1948. In 1954, he left the University to serve a two-year appointment as Visiting Professor of Electrical Engineering at Bengal Engineering College, Calcutta (Sibpur), India. Prof. Benedict has also spent time in industry with several companies including General Electric Company and Line Material Company. He has written one very successful book entitled "Industrial Electronics" published by Prentice-Hall in 1951. He is a member of the American Society for Engineering Education, Sigma Xi, Eta Kappa Nu, and Tau Beta Pi.

Charles Titsworth Button (AM '26, M '46), sales manager, Motor and Contracts Division, Wright Machinery Company, Division of Sperry Rand Corporation, Durham, N. C., has been transferred to the grade of Fellow in the AIEE "...for his contributions to the theory and design of small motors and aircraft inverters." Mr. Button was born in Riverside, Calif., December 11, 1901. He graduated from the University of Cincinnati in 1925 as an electrical engineer. Upon graduation, he joined Union Gas and Electric Company, Cincinnati, Ohio, as an assistant engineer from 1925 to 1926. In 1926, he was employed as an assistant sales manager by Holtzer-Cabot Electric Company, Boston, Mass., where he progressed through various departments until 1944. Mr. Button moved to Dayton, Ohio, and from 1944–47 was employed by Master Electric Company as manager of the electrical control division. From 1947–50, he was vice-president in charge of sales for the Howell (Mich.) Electric Motor Company. In 1950, Mr. Button joined the National Pneumatic Company, Inc., as manager, motor sales, of the Holtzer-Cabot Division until 1956. He went to Wright Machinery Company Division, Sperry Rand Corporation as sales manager of Motor and Contracts Division in 1956 and still holds this position.

Laurence Koehl Del'Homme (AM '18, M '32), superintendent of engineering, Houston Lighting and Power Company, Houston, Tex., has been transferred to the grade of Fellow in the AIEE "...for contributions to the development in an area having a rapid growth." Mr. Del'Homme was born in Houston, Tex., October 27, 1894. He received a bachelor of science degree in electrical engineering from the University of Texas in 1916. He studied toward the electrical engineer degree during 1917, but was interrupted when World War I was declared. From 1918 through 1919, he was instructor at the Air Service Radio School and head of the vacuum tube division at Penn Field, Tex. Upon discharge from military service at the termination of the war, Mr. Del'Homme joined Denver (Colo.) Gas and Electric Company as a research and laboratory test assistant. In 1919, he was employed by the United Water, Gas and Electric Company, Hutchinson, Kans., progressing from superintendent of recovery (electric and water) to superintendent of transmission and distribution, before terminating in 1922. From 1922–25 he worked for the Salina (Kans.) Gas and Electric Company as superintendent of the electric department. In 1925, Mr. Del'Homme joined the Houston (Tex.) Lighting and Power Company as assistant superintendent of engineering, progressing through various phases to the present position of superintendent of engineering. He has been instrumental in improved economically produced services to the area served by the utility. He is a member of the International Association of Electrical Inspectors, and Tau Beta Pi. Mr. Del'Homme has served on the AIEE Committee on General Power Applications (1937–38).

William Jasper Dowis (M '42), principal engineer, design section, Hanford Atomic Products Operation, General Electric Company, Richland, Wash., has been transferred to the grade of Fellow in the AIEE "...for his contributions in the application of electrical engineering to the field of nuclear reactors." Mr. Dowis was born in Idaho Springs, Colo., August 24, 1908. He received a bachelor of science degree in electrical engineering from the University of Colorado in 1930. In the early years of his professional life, he was associated with the Hudson Coal Company, the Buffalo Niagara Electric Corporation, the Remington Arms Company, and E. I. du Pont de Nemours Company (Inc.) in various engineering capacities. Since 1947, he has been with the General Electric Company at the Hanford plutonium production plant, where, as an engineer responsible for the design of electrical systems, and later as a consultant on matters involving electrical design or the forming of design concepts for nuclear plants intended for both plutonium and power production, he has made substantial contributions to the engineering effort that has gone into the billion dollar Hanford plant. Mr. Dowis is past chairman of the Richland Section, and a registered engineer in the States of New York and Washington. He has served on the following AIEE Committees: General Industry Applications (1951–52), and Nucleonics (1953–56).

George David Floyd (AM '19, M '28), assistant general manager–engineering, Ontario Hydro, Toronto, Ont., Canada, has been transferred to the grade of Fellow in the AIEE "...for his planning and direction of the technical growth of a large electric utility system." Mr. Floyd was born in Westville, Nova Scotia, October 21, 1892. He received a bachelor of science degree in 1915 from McGill University. From 1915 through 1917, he was an instructor in electrical engineering at Cornell University while he was engaged in postgraduate studies at the school. In 1917, Mr. Floyd joined the Royal Flying Corps and Royal Air Force, until his discharge in 1919. At that time, he was employed by the Ontario Hydro as an assistant laboratory engineer, and progressed through various jobs and positions to assistant chief electrical engineer before his transfer in 1939 to the newly formed planning division. In 1941, he was appointed chief technical assistant, planning section, electrical engineering department. In 1949, Mr. Floyd was named system planning engineer, system planning department. He held this position until 1952 when he was appointed director of planning, engineering branch. From 1953 to 1954, he was deputy assistant general manager, and was then promoted to assistant general manager, which position he holds to date. He has served on the following AIEE Committees: Membership (1934–36), Electrical Machinery (1935–36), and System Engineering (1948–53). He was vice-president of District 10 (1953–55).

Thomas Daniel Gordy (AM '37, M '44), specialist engineer, General Electric Company, Pittsfield, Mass., has been transferred to the grade of Fellow in the AIEE "...for contributions to the theory, design, and development of transformer magnetic circuits." Mr. Gordy was born in High Point, N. C., October 8, 1915. He received a bachelor of science degree in electrical engineering from the University of North Carolina in 1936. He also attended Rensselaer Polytechnic Institute, receiving a master's degree in elec-

trical engineering in 1948, and a doctorate in electrical engineering in 1955. He is a registered professional engineer in Massachusetts. In 1936–37, he was test engineer with the General Electric Company. He was promoted to power transmission engineering in 1937. He became development engineer, power transformer department, in 1941 and progressed through various stages through 1953. He made several improvements in components and techniques, and holds patent rights on many items. From 1953 to the present, he has been specialist in statistical analysis in the power transformer department. Mr. Gordy has written a number of papers and articles which have been published in AIEE *Transactions*, *Electrical World*, and other publications. He is well known for his many contributions in the transformer core field, as well as mathematical analysis work.

William Talman Hess (M '39), vice-president and chief engineer, Louisiana Power and Light Company, New Orleans, La., has been transferred to the grade of Fellow in the AIEE "...for his contributions in the development of electric power production, transmission, and distribution systems." Mr. Hess was born in New Orleans, La., September 29, 1900. He attended Tulane University, receiving a bachelor of engineering degree in mechanical and electrical engineering in 1922. Upon graduation, and until 1924, he was a student engineer at the General Electric Company, Schenectady, N. Y. Mr. Hess then joined New Orleans Public Service, Inc., as a distribution engineer until 1926. From 1926 through 1927 he worked for Habana Electric Company in the same capacity. He resumed association with New Orleans Public Service as power sales engineer through 1928. Mr. Hess then joined Louisiana Power and Light Company, and from 1928 to 1937 rose through the ranks from industrial engineer to chief engineer, which position he still holds in addition to being vice-president of the company.

William D. Kyle, Jr., (AM '37, M '44), president, Kyova Fiber Pipe Company, Milwaukee, Wis., has been transferred to the grade of Fellow in the AIEE "...for his contributions to the development of components for electric power distribution." Mr. Kyle was born in Milwaukee, Wis., May 18, 1915. He received a bachelor of science degree in administrative and electrical engineering from Cornell University in 1936. From 1936 to 1937, he was an engineer-in-training with the Wisconsin Electric Company. In 1937, Mr. Kyle joined Line Material Company as engineer developing a variety of products in the laboratory. He stayed until 1939, when he became president of the Kyle Company which was formerly Electrical Connectors and Manufacturing Company, and which, since 1948, is a department of Line Material. Mr. Kyle was executive vice-president of the company from 1947 to 1949. He has been instrumental in improvements in many designs, and holds patents on several switches, line sectionalizers, oil circuit reclosers, fuses and cores, etc. At present, he is president of the Kyova Fiber Pipe Company which he organized for the express purpose of manufacturing nonferrous pipe.

Edward E. Lynch (AM '27, M '35), systems engineer, General Electric Company, West Lynn, Mass., has been transferred to the grade of Fellow in the AIEE "...for his contributions in the fields of electrical instrumentation and control." Mr. Lynch was born in Easthampton, Mass., August 20, 1903. He received a bachelor and master of science degree in electrical engineering from Massachusetts Institute of Technology in 1926. Mr. Lynch joined the General Electric Company as an engineering assistant, Meter Engineering Division, in 1926. From 1929 to 1934, he was with General Electric, S. A., Rio de Janeiro, Brazil, where he became manager of the Meter Factory. He returned to the meter and instrument department, West Lynn, Mass., in 1934. In his present position as systems engineer, his responsibilities are associated with the objective of assuring that the instrument department products operate satisfactorily in systems for which they are designed in spite of variations in the users portion of the system or in the conditions under which they must operate. Mr. Lynch holds several U. S. patents, and is the author of articles that have appeared in various technical publications. He is a member of the Institute of Aeronautical Sciences, Army Ordnance Association, Institute of Radio Engineers, National Society of Professional Engineers, Massachusetts Society of Professional Engineers, and Engineering Societies of New England. Mr. Lynch has served on the following AIEE Committees: Nucleonics (1952–56), and Instruments and Measurements (1952–56).

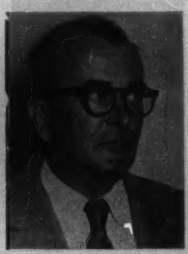
Leon Podolsky (M '45), technical assistant to the president, Sprague Electric Company, North Adams, Mass., has been transferred to the grade of Fellow in the AIEE "...for his leadership and contributions in the field of electronics." Mr. Podolsky was born in Philadelphia, Pa., November 3, 1910. He received a diploma in electrical engineering from the Drexel Institute of Technology in 1933. He was a research fellow in medical physics at Temple University Medical School from 1936 to 1937. From 1929 to 1932, he was with the Victor Talking Machine Company as a development and test engineer. In 1932, he joined the Erie Resistor Corporation where he was research and development engineer until 1934. During the years from 1934 through 1938, Mr. Podolsky was self employed as a consulting engineer, and developed several items such as resistors, circuit switches, and magnetic cores. He joined Sprague Products Company in 1938 and was research engineer until 1946 when he was transferred to Sprague Electric Company as manager of field engineering. He was raised to technical assistant to the president in 1952 and continues in that capacity to the present. He is president of the Greylock Broadcasting Company and vice-president of the Sun Printing Company. Mr. Podolsky is a member of the advisory committee of both North Adams State Teachers College, and Pittsfield Technical High School. He holds several patents on various items he has developed and has written many papers and articles which have appeared in nationwide publications.

Ellery H. Raddin (AM '36, M '43), technical advisor, Champion Lamp Works, Lynn, Mass., has been transferred to the grade of Fellow in the AIEE "...for his accomplishments in applying engineering principles to the development of new light sources." Mr. Raddin was born in Saugus, Mass., November 16, 1885. He graduated from the special engineering course given by the General Electric Company, Lynn, Mass., in 1908. He took further studies at Massachusetts Institute of Technology, Boston University Extension, Lynn and Salem Y.M.C.A., and the International Correspondence School. From 1908 through 1910 he was assistant to the chief lamp inspector at the Electrical Testing Laboratories, Lynn, Mass. He then joined the Champion Lamp Works, and from 1910 through 1952 he progressed through various departments until he became chief engineer in complete charge of six graduate engineers and 16 technical assistants. From 1952 to the present, he has been the techni-

W. J. Dowls

G. D. Floyd

T. D. Gordy



W. T. Hess

W. D. Kyle, Jr.

E. E. Lynch

Courtesy Kantor Studio

Leon Podolsky

E. H. Raddin

cal advisor at Champion Lamp Works. He was chairman of the Lynn Section of AIEE, 1938–9; and chairman of New England Section of Illuminating Engineering Society 1943–4. He is a registered professional engineer in Massachusetts. He was coauthor of several papers, and the author of articles which appeared in *Illuminating Engineering*. Mr. Raddin has lectured to many organizations on light sources, manufacture and development of incandescent and fluorescent lamps.

Walter Schaelchlin (M '46), assistant manager, control engineering, Westinghouse Electric Corporation, Buffalo, N. Y., has been transferred to the grade of Fellow in the AIEE "...for his control engineering achievements in the field of industry and marine propulsion." Mr. Schaelchlin was born in Switzerland, July 30, 1895. He attended State College, Zurich, Switzerland, graduating in 1919 as an electrical engineer. From 1919 to 1921, he was employed by Sprecher and Schuhe in Switzerland in development and test work. This was followed by two years with Brown Boveri in Switzerland as a test engineer for control apparatus. He came to the United States in 1923 and spent two years with Allis-Chalmers Manufacturing Company in transformer engineering. In 1925, he joined the Westinghouse Electric Corporation and worked on railway control, design of regulators, and equipment application. In 1930, he was named section manager of the marine section of the control engineering department where he played a prominent role in the development of electric propulsion control for submarines and surface vessels of many types and classes. At the end of World War II, he received a citation from the Chief of the Bureau of Ships for his outstanding contributions to the war effort. In 1948, Mr. Schaechlin was promoted to assistant manager of the control engineering department. He has been granted 52 U. S. patents, between the years 1928 to 1954. He has written a total of 13 papers which have been published in leading technical magazines or in professional society transactions. Mr. Schaelchlin has served on the AIEE Committee on Industrial Control (1947–49, 1950–54).

Royal Daniel Sloan (AM '17, M '28, Member for Life), dean of engineering, State College of Washington, Pullman, Wash., has been transferred to the grade of Fellow in the AIEE "...for his contributions as an educator and administrator." Dean Sloan was born in Mt. Vernon, Mo., June 29, 1891. He received a bachelor of science degree in electrical engineering from the University of Montana in 1913, an electrical engineer's degree from Montana State College in 1921, and a master of science degree in electrical engineering from Massachusetts Institute of Technology in 1936. Dean Sloan began his career as an educator in 1916 as an instructor in the electrical engineering department of Montana State College. He became assistant professor in 1919, after having spent two years in the U.S.N.R. as a training and assistant engineer and officer, *U.S.S. New Mexico*, Main Engines Division. He spent one year teaching at Yale University and then, in 1923, joined the faculty of the State College of Washington as associate professor in the electrical engineering department. He became professor and head of the department in 1928 and dean of engineering in 1941. Dean Sloan is a member of the American Society for Engineering Education.

John Wallis (AM '31, M '39), chief planning engineer, Oklahoma Gas and Electric Company, Oklahoma City, Okla., has been transferred to the grade of Fellow in the AIEE "...for his accomplishments in power transmission and distribution design and in system planning." Mr. Wallis was born in Kingfisher, Okla., June 10, 1899. He received a bachelor of science degree in electrical engineering from the University of Oklahoma in 1924. After graduation, he took special graduate student courses with the Westinghouse Electric Corporation including transformer test from 1924 to 1925. Mr. Wallis then joined the Oklahoma Gas and Electric Company as engineer, electric lines and substations in 1925, and was promoted to transmission-distribution engineer in 1931. He held this position until 1936 when he became the chief planning engineer, the position he holds at present. During his many years with Oklahoma Gas and Electric Company, Mr. Wallis has originated major engineering application methods in transmission line design, system planning procedures, and transformer peak load calculations which have been adopted by other large electric utilities. Mr. Wallis was chairman of the Oklahoma City Section of AIEE, 1941–42. He is a member of the Missouri Valley Electric Association.

Raymond Rex Wisner (AM '23, M '46), consulting engineer, Stone and Webster Engineering Corporation, Boston, Mass., has been transferred to the grade of Fellow in the

Walter Schaelchlin

Courtesy Hutchison Studio

R. D. Sloan

Hal Owen Photo

John Wallis

R. R. Wisner

AIEE. "...for his application of electrical engineering to the design of power plants and the problems of industry." Mr. Wisner was born in West Unity, Ohio, November 2, 1888. He received a bachelor of science degree in electrical engineering from the University of Washington in 1912. He joined Stone and Webster after graduation, working at Fresno, Calif., in charge of substation design at Eagle Rock Substation of the Big Creek Development. Then followed a period with San Joaquin Light and Power Company in field work, and later as operator, chief operator, and assistant superintendent at Tule River, Calif. He rejoined Stone and Webster in 1915, becoming an engineer in the Electrical Division in 1919. In 1927, he spent several months in Poland, preparing a report on a proposed government franchise for transmission lines and power plants. He was given the tital of electrical engineer in 1927, and during the years which followed, his assignments included about 70 projects for a wide range of industrial and utility clients and for the United States Government. In 1941, he was made assistant chief electrical engineer. During the war years of 1943–45, he acted as an assistant project engineer on the Manhattan Project in the electromagnetic process for production of Uranium-235 at Oak Ridge, Tenn. In 1953, he was made chief electrical engineer in charge of all electrical engineering activities on all Stone and Webster projects. In 1954, he was given the title of consulting engineer, acting as adviser and consultant on a wide variety of problems and as a special consultant to the Atomic Energy Commission. Mr. Wisner has written several articles for technical journals. He is a member of the Massachusetts Society of Professional Engineers and the Engineering Societies of New England. He is a registered professional engineer in the States of Massachusetts, Missouri, and Washington. He has served on the AIEE Committee on Power Generation (1949–56).

AIEE PERSONALITIES

G. R. Henninger (AM '22, F '43), professor and assistant director, Engineering Extension Service, Iowa State College, Ames, Iowa, will direct the study of technical institute education in the United States planned by the American Society for Engineering Education. Mr. Henninger, a graduate of the University of Southern California, started his career with the Westinghouse Electric

G. R. Henninger

Corporation, Pittsburgh, Pa., where he was engaged in design and development of relay equipment. Later he became a member of the staff of the California Edison Company. His first editorial position was with McGraw-Hill as associate editor of *Electrical West*. In 1931, he became associate editor of *Electrical Engineering* and from 1933 to 1948, he acted as editor. In 1942, he served as civilian consultant to the Secretary of the Navy. He was later commissioned a lieutenant colonel in the U.S. Army and served as a technical publications officer at Wright Field, Dayton, Ohio. Before joining the staff of Iowa State College in 1950, Mr. Henninger had been editor of *Illuminating Engineering* and director of publications, Illuminating Engineering Society. He is an active member of the American Society for Engineering Education, Iowa Engineering Society, National Society of Professional Engineers, and Eta Kappa Nu.

J. D. Tebo (AM '36, F '51), editor of the Bell Laboratories *Record* and the Bell System Technical Journal, will edit only the latter publication. Dr. Tebo received the degrees of bachelor of engineering in 1924 and doctor of engineering in 1928 from the Johns Hopkins University. In 1924 and 1925 he took the student training course in meter and relay operating at the Westinghouse Electric Corporation, East Pittsburgh, Pa. His association with Bell Telephone Laboratories began in the summers of 1926 and 1927, continuing in 1928, at which time he was engaged in electromagnetic design, particularly as applied to co-ordination between power and telephone lines. In 1938, he was put in charge of the machine switching laboratory. During World War II, he was concerned with the development and manufacture of radar and sonar equipment for use by the Armed Forces. Following the war, he returned to machine switching and in 1949 became science editor of the Bell Laboratories *Record*. He was appointed Editor of the Bell System Technical Journal and of the Bell Laboratories *Record* in 1953. Dr. Tebo has served AIEE on the following committees: Basic Sciences (1937–55, chairman 1946–48); Communication and Science Co-ordinating (1947–49, chairman 1948–49); Science and Electronics Co-ordinating (1949–52, chairman 1949–50); Computing Devices (1948); Standards Committee (1946–48); Technical Program (1946–50); Award of Institute Prizes (1948–50); Planning and Co-ordination (1948–50; 1954–55); Technical Advisory (1950–52); Publication (1951–56); Sections (1951–53); Liasson Representative on Standards (1951–54); and Technical Operations (1952–55, chairman 1954–55). He is also a member of the American Standards Association, a licensed professional engineer, a member of Sigma Xi, and the Montclair Society of Engineers.

W. R. G. Baker (AM '19, F '47), vice-president and general manager of the Electronics Division, General Electric Company, Syracuse, N. Y., was elected president of the Radio-Electronics-Television Manufacturers Association (RETMA) at its 32nd annual convention in Chicago, Ill. Dr. Baker, one of the country's pioneers in radio, has been associated with the industry for the past 30 years. Born in Lockport, N. Y., he was graduated from Union College in 1917. He joined the General Electric Laboratory in Schenectady, N. Y., the same year. He has been a member of the Board of Directors of RETMA and director of its engineering department since 1934. In this capacity, Dr. Baker has led the electronics industry through numerous technical difficulties and has won national acclaim for his work as chairman of two National Television Systems Committees which developed standards for black and white television in 1941 and color television in 1953. RETMA awarded Dr. Baker its Medal of Honor in 1953 for outstanding contributions to the industry. Dr. Baker has served on the following AIEE Committees. Award of Institute Prizes (1947–48, 1949–52); Electronics (1945–46, chairman 1945–47); Standards (1945–47); Technical Program (1945–48); Communication and Science Co-ordinating Committee (chairman 1947–48); and Planning and Co-ordination (1947–50).

A. C. Abbott (M '46), vice-president in charge of distribution, The Shawinigan Water and Power Company, Montreal, Que., Canada, has been elected president of the Canadian Electrical Association for the 1956–57 session. Mr. Abbott was born in Senneville, Que. He attended McGill University, receiving a bachelor of science degree in mechanical engineering in 1925, and the same degree in electrical engineering in 1926. Following graduation, he was employed by The Shawinigan Water and Power Company as a student apprentice. In 1928, he was appointed assistant superintendent of the Beauharnois Electric Company, Ltd., and became superintendent of that company the following year. In 1930, he was made distribution engineer for the newly formed commercial and distribution department of The Shawinigan Water and Power Company. He became electrical engineer of the department in 1938, and in 1942, transferred to the Company's head office in Montreal to act as priorities officer for the company in its dealings with the Department of Munitions and Supply. In 1945, he returned to the commercial and distribution department as electrical engineer with general supervision over operation and engineering. He was appointed assistant manager in 1947, manager in 1950, and in 1952, was made vice-president in charge of distribution. Mr. Abbott is a member of the Engineering Institute of Canada, the Corporation of Professional Engineers of Quebec, and the Canadian Electrical Association.

M. N. Waterman (AM '49), assistant commercial engineering manager of the Westinghouse Electric Corporation's Lamp Division, Bloomfield, N. J., has been elected president

of the Illuminating Engineering Society. His term becomes effective October 1, 1956 and extends to September 30, 1957. Mr. Waterman has been active in the lighting industry for more than 25 years. A graduate of Massachusetts Institute of Technology, his first professional post was with the street lighting department of the General Electric Company. After a year he joined the Central Hudson Gas and Electric Corporation, Poughkeepsie, N. Y., remaining 15 years, first as a member of its lighting sales and application group and then as director of the unit. Before joining Westinghouse in 1948, he had served with the Government's Technical Industrial Intelligence Committee mission in England and was a member of the executive staff of the Electrical Testing Laboratories, Inc. Mr. Waterman has been affiliated with the International Commission on Illumination, the American Standards Association, the Edison Electric Institute, and the French Illuminating Engineering Society. He has served on the AIEE Committee on Production and Application of Light (1950–55).

OBITUARIES

Robert Orion Hopkins (AM '43, M '52), substation engineer, Gulf States Utilities Company, Beaumont, Tex., died August 19. Mr. Hopkins was born in Fort Worth, Tex., December 26, 1906. He attended Texas A and M College, receiving a bachelor of science degree in electrical engineering in 1928. He joined Gulf States Utilities Company after graduation as a student engineer. He became distribution engineer in 1930, transmission engineer in 1936, and relay engineer in 1940. He assumed his last position as substation engineer in 1950. Mr. Hopkins was a registered engineer in the State of Texas and a member of the National Society of Professional Engineers. He served on the AIEE Committee on Relays (1950–56).

Charles Edward Bennett, (M '15, F '25, Member for Life), retired manager of the Oilostatic department, The Okonite Company, Passaic, N. J., died August 31. Born in Columbia, Pa., in 1882 and a graduate of the University of Pennsylvania, Mr. Bennett had been granted many patents including one for the widely used high pressure pipe-type electric transmission system. He designed and supervised the construction of the country's first 100-kv substation and the first 110-kv transmission line. During his career, he served as cable engineer with the Allegheny County Light Company, as research engineer of the New York Central Railroad, as an engineer with J. G. White and Company, and as both electrical and general engineer for the Georgia Power Company. In 1930, Mr. Bennett joined The Okonite Company where he developed and introduced the Oilostatic underground electric transmission system now in general use for carrying large blocks of power at voltages up to 230 kv. After Mr. Bennett retired as manager of Okonite's Oilostatic department in 1951, he continued his active interest in electrical research and development work. He was a member of the Franklin Institute and of the National Society of Professional Engineers. During World War II, he served in an advisory capacity to the National Inventors Council.

Scott Helt (M '49), patent administrator at Allen B. Du Mont Laboratories, Inc., Clifton, N. J. died August 9. He was 49 years old. Mr. Helt, born in Prichard, Ala., was a veteran in the radio and television industry having been active in radio broadcasting and television for a period of 32 years. Prior to his position as patent administrator at Du Mont, he had been in charge of professional relations for the company and before that was chief engineer of the Du Mont Television Network. He joined the Du Mont organization in 1944. Before his association with Du Mont, Mr. Helt served as engineer and chief engineer in a number of radio stations in the south and midwest, including stations in Columbia, S. C.; Lexington, Ky.; Mobile, Ala.; and Indianapolis, Ind. He was an authority on television engineering practices and served as a lecturer in electrical engineering and as an instructor in "Principles and Practice of Television" at Columbia University. He wrote the authoritative television engineering book "Practical Television Engineering" and was also the author of a number of technical papers published in leading electrical journals. Mr. Helt was a member of the Institute of Radio Engineers, Society of Motion Picture and Television Engineers, American Association for the Advancement of Science, and the Radio Society of Great Britain. He served on the following AIEE Committees: Television and Aural Broadcasting Systems (1951–56), and Electronics (1952–56).

Abraham S. Benjamin (AM '20, M '51), chief, Sales Methods Division, Teletype Corporation, Chicago, Ill., died recently at the age of 62. Mr. Benjamin was born in Chicago, Ill., January 2, 1894. He joined the firm in 1917, shortly after receiving his degree in electrical engineering from Armour Institute (now the Illinois Institute of Technology). He held various executive posts with the company, mainly in the sales division. Mr. Benjamin made substantial contributions to the growth of printing telegraphy and its general acceptance as a basic communication tool. He had numerous patents to his credit, particularly in station selection and remote control. He wrote articles for such publications as *Armour Engineer*, and presented papers at engineering meetings and at conventions of organizations interested in communications, such as the Association of American Railroads and various municipal, fire, and police groups. He served on the AIEE Committee on Telegraph Systems (1949–56).

Hylon Theron Plumb (AM '03, M '21, F '41, Member for Life), retired district engineer, General Electric Company, Salt Lake City, Utah, died August 18, at the age of 82. He was born June 21, 1874, in Milton, Wis. In 1901, he was one of the earliest recipients of the degree of bachelor of science of electrical engineering from the University of Wisconsin. He served as assistant and associate professor of electrical engineering at Purdue University, after which he joined the General Electric Company. In 1912, he was transferred from the Denver office to Salt Lake City, remaining there until his retirement in 1939. He was awarded the General Electric Charles A. Coffin Certificate of Merit in 1925. Dr. Plumb was well known for his public lectures delivered before numerous scientific, professional, and educational groups. He was a member of the Utah Academy of Sciences, Engineering Council of Utah, Utah Society of Professional Engineers, Mineralogical Society of Utah, Northwest Electric Light and Power Association, Tau Beta Pi, and Sigma Xi. Dr. Plumb served on the following AIEE Committees: Membership (1922–25), Electrochemistry and Electrometallurgy (1923–24), and Code of Principles of Professional Conduct (1936–40).

Charles Herman Trommer (AM '40, M '47) electrical engineer, Pioneer Service and Engineering Company, Chicago, Ill., died recently. Mr. Trommer was born December 25, 1907, in Witten, Germany. He graduated from the University of Illinois, receiving his bachelor of science degree in electrical engineering in 1933. Upon graduation, he served as engineer and consultant in the mining field. He became associated with the predecessors of Pioneer Service and Engineering Company in 1945. Mr. Trommer served on the AIEE Committee on Power Generation (1955–56).

MEMBERSHIP

Applications for Election

Applications for admission or re-election to Institute membership in the grade of Member have been received from the following candidates, and any member objecting to election should so notify the Secretary before October 25, 1956, or December 25, 1956, if the applicant resides outside of the United States, Canada or Mexico.

To Grade of Member

Alden, R. M., chief engineer, Hawaiian Telephone Co., Honolulu, Hawaii.
Armistead, I. C., Jr., assistant to Director of Product Development, IBM Corp., New York, N. Y.
Blodgett, R. B., research director, Okonite Co., Paterson, N. J.
Elvy, M. T., chief engineer, Industrial Electronic Division, Redifon, Ltd., London, England.
Evans, F. C., manager of Research & Development Division, ADT Co. Inc., New York, N. Y.
Faulkner, W. H., Jr., chief engineer, Industrial Division, Tracerlab, Inc., Boston, Mass.
Ford, W. R., chief engineer, Reynolds Electrical & Engineering Co., Eberline Instrument Division, Santa Fe, N. Mex.
Hogan, W. H., engineer, Iowa-Illinois Gas & Electric Co., Davenport, Iowa.
McAllister, J. G., head of Electrical Engineering, Courtauld's (Canada) Ltd., Cornwall, Ontario, Canada.
Owens, B. H., electrical systems engineer, Testing Division, Douglas Aircraft Co., Santa Monica, Calif.
Preston, L. E., assistant chief engineer, Induction Motor Division, A. O. Smith Corp., Tipp City, Ohio.
Reddie, J. S., engineer, General Electric Co., Richland, Washington.
Spaugh, F. M., manager-Marketing Research & Planning, Rectifier Dept., General Electric Co., W. Lynn, Mass.
Taras, A., patent agent, IBM Corp., Endicott, N. Y.
Thomas, H. O., electroplating circuit engineer, General Electric Co., W. Lynn, Mass.
Thompson, H. A., consulting engineer, Union Switch & Signal Division, Westinghouse Air Brake Co., Pittsburgh, Pa.
Toivonen, E. O., production manager, Electronics Corp. of America, Cambridge, Mass.
Werhan, F. L., chief electrical engineer, Central Kansas Power Co., Hays, Kans.
Winn, E. C., Jr., project engineer, Connecticut Telephone & Electric Corp., Meriden, Conn.
Young, L., fellow engineer, Westinghouse Electric Corp. Baltimore, Md.

20 to grade of Member

ELECTRICAL ENGINEERING EDUCATION

AIEE in University of Pittsburgh

THE STUDENT BRANCH of the AIEE at the University of Pittsburgh was organized on October 6, 1915, under the leadership of Prof. L. H. Harris. The first meeting was attended by 16 students who elected G. R. Patterson as chairman; R. C. Zindel as vice-chairman; and W. K. Benz as secretary.

At the time the organization was perfected, the electrical engineering department numbered some 40 students with 8 or 10 seniors and 2 men on the teaching staff. Today the department numbers 500 students (undergraduate and graduate), with a staff of 20 or more teachers. The trend is still upward. The Schools of Engineering and Mines are housed in four buildings located on the University's upper campus. One of these is a new $2 million engineering building completed last September.

The major portion of the University of Pittsburgh administrative offices are housed in the Cathedral of Learning (right) which provides most of the classroom space together with library facilities, food service, and other important services. The Cathedral is one of the most unusual and beautiful college buildings in the United States. Architecturally, it is a modern adaptation of the Gothic tower, modified to the practical needs of a university, and suggesting in height and reach the spiritual values which underlie university education. The building rises 42 stories or 535 feet. It has a space volume of 9 million cubic feet.

Courtesy University of Pittsburgh

To All Students of Electrical Engineering

M. S. COOVER
PRESIDENT AIEE

MY CORDIAL AND MOST SINCERE greetings to each of you. I am sure you realize that our colleges and universities are doing their best to give the undergraduate student the most comprehensive basic training possible within the traditional 4-year academic period. This is with the hope that the graduate may enter his chosen profession sufficiently well equipped to accept employment of a technical nature or to proceed successfully with a graduate study program. After graduation, one usually finds his early assignments to be associated with some kind of on-the-job training of a formal nature, or otherwise. In any case, he launches upon his professional career and his employer rightfully expects him to make progress.

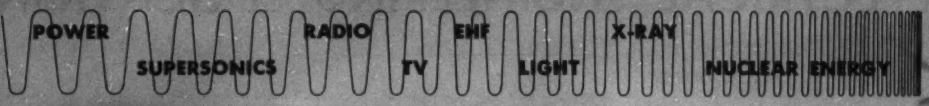
M. S. Coover is Associate Dean, Division of Engineering, Iowa State College, Ames, Iowa.

Preparation

Very rarely, a student upon entering college knows who his future employer will be upon graduation or the responsibilities that may come to him on that initial employment. It, therefore, becomes highly essential that the best preparation be made while in college, so that when challenges do come, thrills and satisfaction will be experienced rather than disappointments and frustration. Sometimes a student takes an unfavorable attitude toward certain required courses, thus hampering no one but himself. Often one hears a student remark, "Why should I be compelled to take this or that course when I know that it will never do me any good?" But how does he know? What valid basis is there for such judgment? Fortunately, curriculum content results from sound advice given by employers who have adequate background experience and seasoned judgment. Cognizant of this advice, faculties tailor curricula to the traditional 4-year period and, then, exert their best efforts on instruction.

Probably no other classified field of engineering expands so rapidly as does that of electrical engineering and its associated sciences. For this reason, the content of the undergraduate curriculum in electrical engineering must constantly be reviewed and upgraded. For the student of electrical engineering to be as well prepared as possible to take his place happily upon graduation, his college study program must contain more and more basic concepts, leaving specialization for his employer to guide. Employers also expect the graduate to have a comfortable appreciation for the importance of his college training in the social and humanistic areas. Present-day curricula in electrical engineering are being broadened, so that the graduate may start his specialization after graduation in any facet of electrical

Electrical Engineering Education



M. S. Coover

engineering in which he may choose to accept employment.

What every student needs, probably more than anything else when he arrives on the campus, is friends. If he himself is kindly and friendly, others will enjoy his company. They will be interested in his thoughts and decisions. The same holds true when launching his professional career after graduation. One cannot expect to make friends effectively unless he has a genuine and sincere desire to be friendly. Everyone knows that first impressions are long lasting and that they can be most valuable regardless of age or experience. One often encounters the statement that, assuming normal capabilities, it is through friends that opportunities come more often than not.

Activities

In reality, professional careers for students of engineering actually start when they enter college and not immediately following commencement. One of the most valuable opportunities for development of those personal characteristics that contribute so much to success is to be found in the student branch of the national professional engineering society that covers the broad scope of one's chosen career. For the student of electrical engineering it is the Student Branch of the AIEE, whether operated on the campus as a separate organization or jointly with another organization. The curriculum in electrical engineering is all-inclusive in its scope, likewise the AIEE is all-inclusive, matching the curriculum in its intended total coverage. A student of electrical engineering cannot make a mistake by early identification with the Student Branch of the AIEE or the Joint Student Branch AIEE-IRE (Institute of Radio Engineers) at his school.

I have heard any number of representatives of employers, when on the campus to interview prospective graduates, state that election to an office in any organization is recognition of potential leadership and that those are the young men whom they want to interview first. It represents recognition of some measure of ability. It adds to human experiences. It makes favorable impression upon teachers, department heads, and college administrators. It looks well on a personnel leaflet and it makes favorable impression upon a prospective employer.

I sincerely urge you to participate as much as possible in your student branch activities. You will find that there are numerous ways of taking advantage of the many opportunities offered by your student branch quite aside from attendance at meetings. Not all meeting programs can be expected to be of the same high level of interest to all students, but this is so in any organization. It should be remembered, however, that the program is only part and parcel of the over-all benefits of what the student branch can offer. What it does actually offer is largely dependent upon the leadership quality of the faculty counselor and the student branch officers. Why not decide that you, too, can and will become a good officer and leader?

It is not my purpose to outline all the advantages of student membership in the AIEE. Those can be found in the "Student Branch Manual." Your counselor, department head, and Student Branch chairman each have copies. I urge you not to spend, but to invest a few minutes of your time to inspect carefully the contents of this manual (even though you may previously have listened to someone present the outline). You will be surprised at the tremendous scope of opportunities that are open to you.

Prize Papers

Seated at a dining table in the Fairmont Hotel in San Francisco, Calif., during the 1956 Annual Summer and Pacific General Meeting were 11 young men, each of whom was introduced during the luncheon. Each was the author of a prize winning paper in his geographic District. Each had received a certificate of award and $25 in cash for the winning paper in his District. But what prompted every one of these 11 young men to be in San Francisco as a group? The AIEE provides travel expense allowances for these young men to attend the annual summer meeting in the same amount that it does for members of the Board of Directors of the national body. These same prize winning papers, along with all other papers presented by students at any regularly stated meeting, are eligible in competition for the national prize of $100 with certificate. Often, credit is given at some colleges as an elective towards graduation for the effort and quality represented by all such papers, whether they are prize winning or not.

Formerly, there was only one winner in each geographic District who received a cash award of $25, a certificate, and a trip to the annual summer meeting. Beginning with the present administrative year of the AIEE, through the Members-for-Life Fund, a special second prize of $25 and third prize of $15 will be awarded in each District to authors of undergraduate student papers, each with a certificate.

You will find more complete information from time to time on Student Branch activities as recorded in the AIEE monthly publication *Electrical Engineering* in the section "Electrical Engineering Education." Each undergraduate and graduate student who is a student member of the national body of AIEE receives this publication. I urge you to become familiar with it, and to make an investment in student membership in the AIEE. Actually, that investment amounts to the price of a few attendances at movies.

You are entirely familiar with the age-old proverb that goes "What the future holds in store for you depends upon what you put in store for the future." A modification of that proverb applies to the AIEE, namely, that it is not what you get out of it that counts, it is what you put into it that counts. That is why 50,000 corporate members of our Institute give so generously and freely of their time and effort throughout their active years. Whoever said that "Success is a journey—not a destination" spoke a real truth. I wish for each and every one of you a full measure of success and happiness as you advance on your journey.

Cordially,

M S Coover

President, AIEE

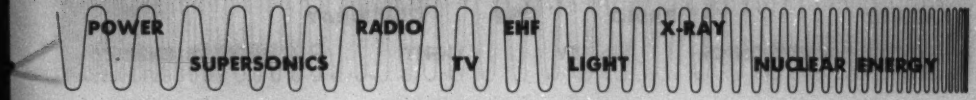
An Engineering Career in the Electrical Manufacturing Industry

C. T. PEARCE
VICE-PRESIDENT AIEE

TODAY, one of the most promising careers open to an electrical engineering graduate is in the electrical manufacturing industry.

Two factors make this so: First, although the total manufacturing industry is growing fast, the electrical manufacturing business is growing at a much faster rate; this implies substantial long-time benefits. Second, because of its extremely broad range of engineered products, the electrical manufacturing industry utilizes perhaps the most diversified engineering talents of any single

Electrical Engineering Education



segment of American industry. For example, the larger electrical manufacturing companies produce: power and industrial apparatus, such as generators, motors, and control (using electronic, static, and contactor devices); electronic and communications equipment, such as radio and television, radar, and guided missiles; mechanical machinery, such as steam and gas turbines, heat exchangers, pumps, and gearing; atomic power equipment, such as reactors, special instrumentation, and even complete power plants; household appliances; and many other items. To do the research, design, and application of such products requires engineers of practically every type—including electrical and electronic, mechanical, industrial, metallurgical, and chemical; plus physicists, mathematicians, and other scientific personnel.

Perhaps a brief discussion of the kinds of work that engineers do in an electrical manufacturing company, a bit about their training program, and some principles that further an engineer's career may help give a better idea of the diversified opportunities in electrical manufacturing.

Major Engineering Activities

The major engineering activities of a large integrated electrical manufacturing company can be classified under the seven functional headings of research, design and development, application, manufacturing, sales engineering, service, and management. The requirements and satisfactions peculiar to each of these are discussed in the following paragraphs:

Research. As a start, the research activity is considered, where the greatest use is probably made of what might be termed basic scientific knowledge. Research work in the electrical manufacturing industry usually falls into two general categories. One category relates to investigations which advance the basic knowledge of a subject, without necessarily having any immediate practical application; this is called basic, or pure research. The other type covers studies of just as fundamental a nature, but which are specifically directed toward the solution of a known problem, such as the development of a new product or the improvement of an existing one—termed applied research.

For a successful career in research, an engineer needs a thorough knowledge of fundamental theory and mathematics, coupled with an inquisitive and open mind. He should also have the courage and initiative to keep on trying for successful results in the face of setbacks. Advanced degrees are held by many engineers who are engaged in research work.

Design and Development. A large number of engineers employed by electrical manufacturing companies are engaged in design and development work. As this title implies, these engineers prepare design and specification data. Therefore, it goes without saying that they should be well grounded in engineering fundamentals, as well as being analytical, creative, and resourceful. They will find it necessary to learn manufacturing practices, in order to take this factor into account in their designs. Also, they should become acquainted with the application requirements of the apparatus which they are developing and designing.

No matter how well designed a piece of electrical equipment may be, it is of little value to either the manufacturer or the prospective user unless it can be manufactured and sold in a competitive market at a reasonable profit. The design engineer should, therefore, strive toward developing a product which has an adequate margin in performance and life, but one which can still be manufactured without incurring excessive costs.

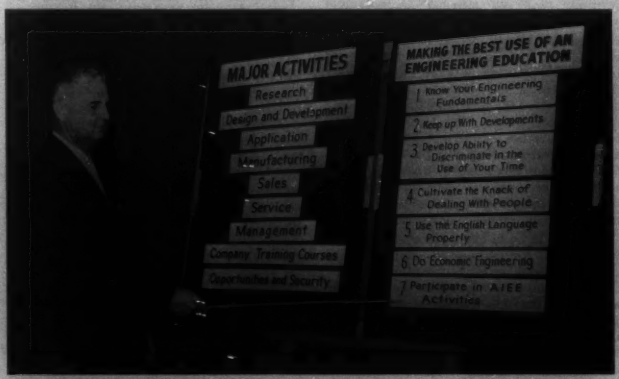
Application. The application engineer, sometimes referred to as the industry engineer or the consulting engineer, concentrates on the problems relating to the application of the apparatus manufactured by his company. He is familiar with the special engineering requirements of equipment, as used in the particular industry to which he is assigned. Practically all major industries have particular requirements of their own on such things as mounting, enclosures, ambient conditions, duty cycle, control circuits, overload capacity, and many others. The application engineer is responsible for the engineering co-ordination of different types of apparatus manufactured by his own company, together with the associated equipment furnished by the user and others, to produce optimum over-all results at minimum total cost.

It should be mentioned that some application engineers become specialists on a particular line of products, as regards application to all industries.

Manufacturing. Many engineers are used in the manufacturing, quality control, and other production activities of an electrical manufacturing company. In this category are included those who lay out the manufacturing aisles to give the proper arrangement and facilities, those who develop the required tools and processes, and those responsible for controlling both the cost and the quality of the finished product. The engineers who test the completed apparatus before shipment can also be included under this general heading. A manufacturing engineer is responsible for the problems involved in all phases of production, and there is never any absence of engineering problems in this field. The increase in the use of automation is making the manufacturing engineer even more valuable and necessary. In fact, it is doubtful whether the challenges and opportunities in the manufacturing field are fully appreciated by many engineers.

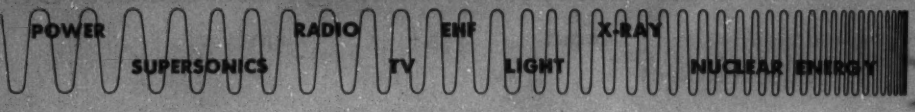
Sales Engineering. The apparatus sales engineer in an electrical manufacturing company is not the type who "rings doorbells" to make his sales. He sells his products to engineers and must, therefore, talk their language. He is frequently responsible for selling several different products, many of which may be of a rather complex nature. This makes it almost essential that he be equipped with technical training; the great majority of sales engineers in an electrical manufacturing company therefore have degrees in engineering.

In addition to having the required knowledge regarding the technical characteristics of the apparatus which he sells, the successful sales engineer is familiar with the policies,



The author suggests seven principles for the graduate to follow in building upon his education.

C. T. Pearce is with Westinghouse Electric Corporation, Philadelphia, Pa.



plans, and problems of the customers whom he handles. He is acquainted with the customer's organization, and he knows the responsibilities and characteristics of the personnel who influence purchases. He will obviously be happiest in this assignment if he enjoys dealing with people.

Service. A force of service engineers is utilized by many electrical manufacturing companies in order to install, repair, and maintain their apparatus in the field. The service engineer necessarily is a technically trained man, who might be said to specialize in the physical aspects of the equipment. He usually follows a somewhat practical approach to a problem. He knows how the apparatus which his company manufactures should be installed and connected. He knows what to look for if trouble occurs and how to fix it promptly. By and large, the service engineer functions only in a supervising capacity in field work, with the necessary skilled and common labor being provided from other sources to work under his direction.

Management. Management assignments may well be the ultimate result of experience in any of the six major fields previously covered. It may not be too generally realized that one third or more of electrical engineering graduates end up in managerial or administrative positions, and some studies indicate that this figure is even higher in the electrical manufacturing industry. A recent Columbia University survey showed that 40 per cent of industrial management is "engineer trained." It is only natural to expect that the percentage of engineers in executive positions will continue to increase as American industry becomes more technical in nature, and an engineering training becomes a requisite for a greater number of key positions. It should be emphasized, in this connection, that promotions are not closed to those engineers in the electrical manufacturing industry who do not enter the field of management. Some engineers simply do not possess administrative ability or temperament, and it should be immediately added that this is in no way peculiar to engineers. Others do not want to be bothered with the headaches which are the inevitable lot of management. These people still have every opportunity to advance by becoming more expert and proficient in their particular engineering fields. Senior engineers in an advisory or consulting capacity frequently draw salaries which are comparable to that received by the engineering manager of the department.

No exact formula can be given, of course, for becoming a supervisor or manager in an electrical manufacturing company. However, it should be obvious that the engineer who desires to progress along managerial lines must supplement his engineering knowledge and experience by also familiarizing himself with such nontechnical matters as employee relations, company organization and policies, accounting procedures, budgets, etc. Many such companies make it possible for an employee to obtain this additional knowledge by special outside training, often on a part-time basis. Obviously, the engineer-turned-manager also must subjugate, to some extent, his native desire to dig too deeply into engineering details, because he simply will not have the time to do so.

Many companies, electrical manufacturers as well as others, have established a so-called management development program, which sets up definite procedures to give deserving employees every opportunity to advance in the organization. The performance and potential of every professional employee, regardless of his position, are analyzed and recorded by his supervisors, at intervals of 1 year or less. The employee is then advised and counseled on his shortcomings, his strengths, and the paths which he should pursue in personal development.

Company Training Courses

Training and orientation courses are conducted for their new engineers by many electrical manufacturing companies. These courses may be of a year or more in duration. They are a real "plus" to the engineering graduate just starting to work. During this period, the recently graduated engineer is taught something about how his particular employer expects to put his college-acquired engineering knowledge to work. He learns more about the duties involved in the various lines of endeavor, and is given a further opportunity to choose the one which is most attractive to him. Substantially equal opportunities exist in any type of work, of course, but the engineering graduate naturally will be of the most worth to his employer and will, therefore, advance more rapidly in the organization, if he selects the activity for which he is best fitted. It goes without saying that he will also be happiest in the field where he is able to accomplish the best results. After the engineering graduate decides upon his chosen line of work, he is given further special training in this particular field.

Mention should also be made of the opportunities given to all employees, young and old alike, for many types of on-the-job training, as well as additional outside schooling. In addition to technical subjects, these outside courses may cover such fields as human relations, economics, effective writing, and public speaking. Some companies have arrangements set up with nearby universities, which enable their engineers to obtain advanced degrees by taking evening courses, with tuition being paid by the company up to the full amount, for those completing the degree requirements.

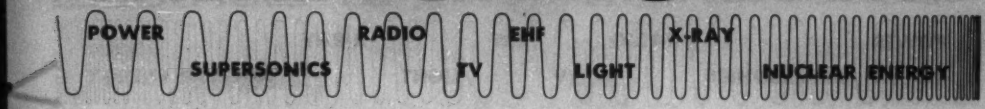
Opportunities and Security

At first glance, lumping "Opportunity" and "Security" under one heading may look like a contradiction in terms. However, a little reflection should show that these two objectives actually go hand-in-hand for the young engineer today. What better guarantee of security can one have than entering a field where there are so many opportunities?

It is not necessary to dwell on the serious shortage of engineers which has existed in this country for several years and which gives every evidence of continuing well into the future, if not indefinitely. The annual needs for additional engineers can be expected to continue growing at a rapid rate. It is largely through the efforts and accomplishments of our technical manpower that we now enjoy a higher standard of living than any other country on the face of the globe. With only about 7 per cent of the world's total population, we produce over 50 per cent of the world's manufactured goods. As might be expected, the number of engineers has necessarily been increasing at a much faster rate in this country than our growth in total population. Estimates vary on the present number of workers per engineer in this country, but a figure of 50 appears to be conservative. It is further estimated that the ratio of engineers to total workers has doubled during the last 25 years, and increased at least fivefold since 1900. Reliable estimates place the ratio of engineers to workers in the electrical manufacturing industry somewhat higher than the national average. Not only our future national prosperity, but our military security as well, will be jeopardized unless we continue to add to the ranks of our technical manpower.

It has been said that there have been more technological advancements made during the past 50 years than in the preceding 5,000. Nevertheless, there is no reason to think that we have still more than just scratched the surface in all fields of engineering, and electrical engineering in particular. For example, far-reaching future developments can undoubtedly be expected in the fields of electronics, atomic power, computers, and communications. Little-publicized, but nevertheless very significant, technical improvements are being made every day in our production machinery, giving the worker more productive capacity, and there will never be an end to discovering ways of performing industrial tasks better and faster. This is exemplified by the current increase in the use of automation. Great strides can be expected in improving living conditions in the home, notably on such items as air conditioning, heating, and cleaning. Experience has shown that every new technical discovery or development opens up new fields of endeavor, which raises further problems and the accompanying need for even more technical people to solve these problems.

Now to return more specifically to the joint topic of "Opportunities and Security." In order to enjoy both, it is, of course, necessary that the engineer working for an electrical manufacturer, or for any other company for that matter, be a loyal, con-



scientious, and co-operative employee. He will be expected to exercise judgment, initiative, and foresight. Perhaps most important of all is that he does the best job of which he is individually capable. If he does all of these things, certainly none of which are unreasonable, he may expect an income and recognition commensurate with his ability, together with a high degree of security.

Making Best Use of an Engineering Education

There are a few broad suggestions which can be made on the subject of how an engineering graduate can build upon his education and otherwise, put it to the best use in a career with an electrical manufacturer. In fact, it is to be expected that many of the following principles would apply to an engineer working in almost any field of industry. These seven points are not intended to be arranged in any particular order of importance.

1. Know and Use Engineering Fundamentals. These fundamentals are drilled into the engineering student in college, but disuse sometimes causes him to forget them after he graduates and starts to work. An engineer is not using all of his tools, if he does not resort to fundamental relations in solving his tough problems. Only through this method can he maintain the proper flexibility in his approach. It must be remembered that a more complete knowledge of fundamentals is one of the biggest advantages that an engineering graduate has over a good practical electrician or mechanic.

2. Keep Up with Developments. There is probably no field where developments and advancements come as fast and furiously as in electrical engineering. Different and better ways of doing a job electrically are being discovered every day. New types of equipment and circuits, embodying new principles, are continually being made available. Naturally, there is far too much specialization today to permit any one electrical engineer, even if he is a genius, to keep fully up to date on developments in all fields of his profession. However, a practicing engineer must keep abreast of the developments affecting his own particular field of activity. Otherwise, he is running a serious risk of some more recent and wide-awake engineering graduate passing him. As has been said before, "education is a journey, not a destination."

3. Develop Ability To Discriminate in the Use of Time. A successful engineer must plan and manage the use of his time. He must try to determine which matters are most important, and then concentrate on those particular items. Minor activities cannot be entirely neglected, of course, but a busy engineer must use judgment and guard continuously against going off on a tangent and spending more time on a relatively unimportant matter than it deserves. This is particularly true if he holds a responsible job, because he is then subjected to pressure from all sides to give certain matters special attention. He has to learn to delegate work to others, particularly subprofessional jobs to technicians and clerks.

Some engineers who become managers never seem to be able to turn loose of an assignment, even after they delegate it to someone else. This unfortunate practice has the effect of destroying the initiative and usefulness of a subordinate, in addition to failing of its purpose to free the manager for more important tasks.

4. Cultivate the Knack of Dealing with People. The engineer is accused, all too often with good reason, of being a poor mixer, a "stick-in-the-mud." He may have a world-beater of an idea, but it is usually not worth much unless he can sell it to someone else, whether it be his superior or a potential user. An engineer must co-operate with his fellow workers and show tolerance for their ideas, whether or not they have the advantage of a college engineering education. He must adapt himself to the routine and system of the company which employs him, although this will undoubtedly prove quite irksome at times. Advancement frequently brings with it the responsibility of supervising the activities of other people, with resulting problems in the field of employee relations. Human nature, unfortunately, cannot be catalogued and reduced to formulas in the same manner as physical phenomena.

An engineer should also recognize his civic responsibilities, as befits a member of his increasingly important profession, and give time to community activities.

5. Use the English Language Properly. Many engineering students regard a course in English as a "necessary nuisance"—in this attitude, they make a big mistake. As one of my professors once remarked, "English happens to be the language we use in this country." An engineer who cannot express himself in good English, in writing as well as orally, is at a definite disadvantage. Also, he cannot gain much of a reputation until he develops the ability to write papers and articles, and to make a passable public speech. In this connection, special reference should be made to the value to the student member of participating in AIEE student prize paper contests. The monetary reward, even to the winner, does not usually compensate contestants fully for the time spent in preparing such papers, and this will continue to be true, incidentally, when they go into industry and start writing papers for professional and trade publications. However, the experience of preparing and presenting student papers, and of competing with other contestants at the Branch and District levels, will prove to be of inestimable value in their subsequent engineering careers.

6. Do Economic Engineering. Engineers must be cost conscious. Good engineering is as much economics as anything else. Despite all the copybook maxims which state that there is only one right way to do something, a good engineer is often forced to strike a compromise between cost and perfection. Many practical examples in the engineering field could be cited to prove this fact. In the final analysis, an engineer's job is to use his ability to develop or to apply the most economical method of satisfactorily performing a given task.

7. Participate in AIEE Activities. This final item is included, not just because this article appears in *Electrical Engineering*, but because it is sincerely believed that AIEE membership and participation is of great mutual benefit to both the electrical engineer and to his profession as a whole. No better proof of this claim can be offered than the very excellent paper by Director L. F. Hickernell, entitled, "AIEE Is a Post Graduate School."[1] AIEE President M. S. Coover has said regarding Mr. Hickernell's paper: "It ought to be required reading for every student of electrical engineering." I feel that its contents will be of almost equal value to the young engineering graduate.

It is worthy of emphasis that AIEE is truly a professional organization. It is much more than just a technical society. AIEE really earns its high professional status by its co-operation and liaison work with other professional engineering societies, both domestic and international.

One quite telling argument for AIEE membership and participation is the very practical fact that its present total membership of some 50,000, excluding student members, takes in practically all of the leading electrical engineers in this country. These men have evidently found this association to be worthwhile in advancing their individual careers, as well as in fulfilling their professional needs. About a year ago, I heard the then President of the American Society of Mechanical Engineers, D. W. R. Morgan, tell a group of mechanical engineering students that "membership in his national engineering society is the best long range investment that a graduate can make."

Just as in anything else, what one gets out of AIEE membership will depend, to a great extent, upon what he puts into it. If he attends the meetings, takes part in committee work, and prepares papers and talks, he will then have an opportunity to rub shoulders with the most prominent men in the electrical industry. He will gain far more from this association if he is an active rather than a passive member.

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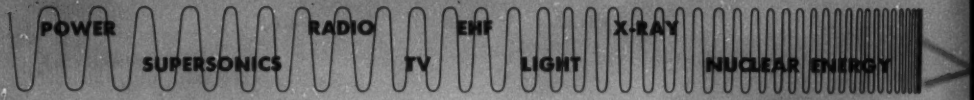


Electrical Engineering Curricula in a Changing World

F. E. TERMAN
FELLOW AIEE

F. E. Terman

IN THE LAST DECADE, important changes have taken place in the education of electrical engineers. These in part, have come in response to new needs. A factor, however, has been an underlying dissatisfaction with the inadequacies of the typical training of the prewar electrical engineer.

The Problem

The great problem involved in the training of electrical engineers today is that there is so much that is worth learning. This comes about because one of the most significant features of present-day technology is the extent to which advanced mathematics, academic physics, and high-brow engineering theory can be used in the solution of electrical engineering problems of great practical significance to industry. There are today few ivory towers that are not stained by the grime of the practical world.

Electrical engineering has become a very complicated subject and is steadily becoming more so. This is true, first, with respect to the level of technology and science with which the electrical engineer of today deals. Thus, a servomechanism is more complicated than a regulator; a television set is much more sophisticated piece of equipment than a radio receiver; and color television involves still further complications. Again, the transistor is more difficult to understand, has more complicated properties, and is far more difficult to manufacture than the vacuum tube which it is beginning to displace. Second, once the engineer creates a new and complicated device, he immediately proceeds to combine it with other equally complicated devices to produce a system that is still more involved. The common combination of a radar set, a servomechanism, and an electronic computer is an example; each of these components is inherently complicated in itself, and the resulting system is even more so.

Thus, the young electrical engineer today must know more engineering and science than was expected of him 20 years ago. In addition to familiarity with electrical circuits and equipment, he must have an ever-increasing knowledge of electronics, be familiar with servomechanisms, and know something about such fields as statistics, atomic and nuclear physics, and solid-state physics. If he becomes involved in a difficult mathematical problem, he is expected to know how to use an electronic computer to get out his answers.

The successful engineer of today has to deal with people and be a part of the world about him. Even the systems that he creates with the aid of mathematics, his knowledge of materials, and from the results of his experiments must be run by human beings and, therefore, matched to them in an appropriate manner. Today, there is universal acceptance of the view that every young engineer must have training in the social sciences and humanities. Gone is the time when, if the freshman engineer passed his matriculation examination in bonehead English, he could happily complete a 4-year program absolutely untouched by such cultural subjects as English, economics, history, psychology, and sociology.

Although the devices and systems of man are steadily becoming more difficult to understand, the children of men are no different from their parents. This is a basic fact from which there is no escape. Although it is easy to devise fine programs of education which achieve progressively higher goals by expecting each new class to be able to learn a little more in the same length of time, this just does not work out in practice, because the ability of our youngsters to learn new things is the same as that of their parents.

As a result of this situation, the need for simplification and for better organization and presentation of the body of engineering knowledge has never before been so great. Ways must be found to teach more material as well as to teach material of greater difficulty to the same kinds of boys in the same length of time. This means making a given subject easier to understand and more general in its applicability.

Today, the young electrical engineer will not achieve his full possibilities in highly technical work unless he acquires a considerable amount of formal training beyond his bachelor's degree, obtained in graduate school, evening school, or a carefully planned industrial training program. Unorganized "on-the-job experience," while valuable, is no substitute for formal training in a field where the technological complexity is increasing so rapidly.

Curriculum Changes To Produce Better Engineers

A number of significant changes are taking place today in curricula for training electrical engineers. First, greatly increased emphasis is being placed on the basic sciences and on fundamental engineering principles, with correspondingly less attention devoted to current engineering practice and to drill in design and computation procedures. Second, the undergraduate years are being used with increasing efficiency. Third, the time devoted to college training is on the average being extended. Fourth, adult education is of growing importance. Fifth, fragmentation of the broad field of electrical engineering is taking place.

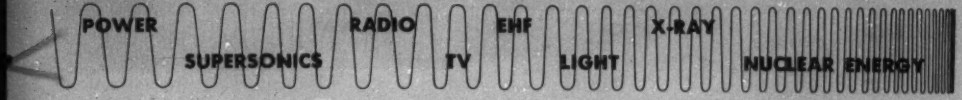
Electrical engineers are today rapidly going back to general principles. No longer is the training of young electrical engineers limited to the detailed development of electrical phenomena at only 0.000 and 60.000 cycles per second (cps), with emphasis primarily on powers of the order of watts or more. The newer curricula are concerned with frequencies from zero to at least 30 billion cps, with powers from micromicrowatts to megawatts, and with wave shapes that are square, sawtooth, pulsed, etc., as well as unidirectional and sinusoidal. No longer is the basic sequence of physics courses in mechanics, heat, and electricity considered as providing comprehensive training of engineers in physics; familiarity with atomic and nuclear phenomena, and with solid-state physics is rapidly becoming a "must for a well-trained electrical engineer." Similarly, mathematics through a smattering of ordinary differential equations no longer represents adequate training for those of our next generation of engineers whose interests are in the more technical matters; these men must know partial differential equations, functions of a complex variable, matrix theory, statistics, numerical analysis, etc.

There is a growing awareness today that the student's time in the undergraduate curriculum is so precious that none of it

Full text of an acceptance address of Members-for-Life Fund Medal presented at the Fall General Meeting, Chicago, Ill., October 1–5, 1956.

F. E. Terman is Dean of the School of Engineering and Provost of Stanford University, Stanford, Calif. Picture supplied by Stanford University News Bureau.

Electrical Engineering Education



should be wasted on knowledge that can be gained almost as well in industry or in acquiring knowledge or skills that will become obsolete in the years ahead. The fundamentals, methods, and attitudes that a young electrical engineer receives from his formal college training must last a lifetime in a world that is constantly advancing. This requires that the focus be more than ever on those basic principles that will continue to be useful and important 10, 20, or even 30 years in the future.

A young electrical engineer can acquire more knowledge that is useful to him by devoting a larger fraction of his life to college training. This is not peculiar to the engineer in this modern world. For example, a doctor was once the product of 1 year of medical training; today, 4 years on top of 4 undergraduate years is a minimum, and no one would want to be treated by a doctor with only 1 year of education in medicine. Thus, graduate work is indicated for those engineers who have ability to profit from more than 4 years of education. They carry this work best either as regular on-campus students or in one of the well-planned work-study programs, in which time off from the job is available for part-time education in college classes. Evening programs are better than nothing at all, but they represent an overload and so cannot be carried at the highest personal efficiency; in addition, in an evening program the rate of progression toward an education goal is necessarily very slow.

Not so many years ago there were very few places in industry where doctorate training in electrical engineering could profitably be applied, and even master's degree training was considered to be of questionable value by many large employers. Today, the more training an electrical engineer possesses, the more versatile and capable he becomes. There is today no such thing as an over-trained electrical engineer. Rather, although there is a shortage of engineers in all categories, the shortage is greater the higher the level of training. Although the salaries offered to men with bachelor training may seem pretty attractive, one should look at the salaries being offered to young men with doctor's training in electrical engineering from good schools!

The character of our rapidly developing technology is such that a young man's initial technical training, however well planned and extensive, is not alone sufficient to carry him through a productive engineering career which lasts a normal life span. Because of this fact, continuing education throughout adult life is a necessity for every engineer who wishes to avoid technological obsolescence. The habit of systematic self study is one of the most valuable qualities a young engineer in industry can develop and is a "must" for the man who desires to get ahead. In addition, it is popular today to supplement such study by short 1- to 8-week adult training programs or conferences, that sometimes deal with technical material and in other cases with administrative subjects. "Catch as catch can" learning from on-the-job experience is not adequate for the needs of the future, let alone those of today, in areas where the technology is new and advancing rapidly.

In looking ahead, increased fragmentation of the broad field of electrical engineering is both inevitable and necessary. Just as electronics grew out of the electric power background of the early 20's, so electronics is now splitting up into such specialities as computers, microwaves, solid-state devices, and automatic controls (servomechanisms). From an educational point of view, this means that educators must devise curricula possessing a basic core which combines those fundamentals that are common to these various specialized but highly important areas of activity and, in addition, allow room for the 4-year student to specialize at least moderately in one or two areas of his choice. This is done in history, economics, mathematics, physics, and chemistry; it can just as well be done in electrical engineering. Certainly, the man who wishes to become an engineer for a public utility company should not be forced to receive the same training as the man who plans to be an electronic-computer engineer.

New Approaches to the Curriculum Problem

Several new ideas in engineering education are currently being explored. There is, for example, the 5-year undergraduate program which was adopted by several well-known engineering schools immediately after the war. Its objective is to relieve the pressure on the 4-year curriculum by using an additional year to provide breadth and depth simultaneously. This movement has not spread, however, and the dominant practice today is to provide the best possible education that can be completed in 4 years, and then to encourage the better men to go on for an additional year or more of graduate training. This makes it possible to operate the fifth year at a higher level and, thus, bring the superior student to a higher terminal point at the end of 5 years than he would in the 5-year undergraduate program.

An interesting departure from convention is the comprehensive or unified engineering curriculum. Here, there is only one basic engineering program, with instruction so organized as to emphasize the similarities between different areas of engineering, instead of the more customary policy of emphasizing the differences. The ideas involved in this approach are of great interest to engineering educators and are having considerable influence on current educational thought. At the same time, the unified engineering curriculum is unlikely to gain full acceptance, because it requires teachers having unusual breadth of knowledge and students with sufficient ability to carry thinking readily from the general to the particular. The unified plan of training also suffers from an insufficient supply of texts designed to meet its needs.

A number of well-established schools now are offering their electrical engineering majors an opportunity to follow a program of study in which such traditional engineering subjects as strength of materials, statics, dynamics, and heat–power laboratory are replaced by additional work in mathematics, physics, and such analytical engineering subjects as electromagnetic theory and Laplace transform. Although electrical engineers who graduate from these curricula may not be able to calculate the strength of a beam, they can tackle many problems in electrical engineering that are more important to their careers, and they will still know how to use the formulas for the beam that are found in a handbook. This is a rapidly growing trend, and it either will force the introduction of more broadly conceived criteria for accreditation of electrical engineering curricula or will bring about a condition in which the best road to technical leadership in the newer areas of electrical engineering will be through following a non-accredited pattern of training.

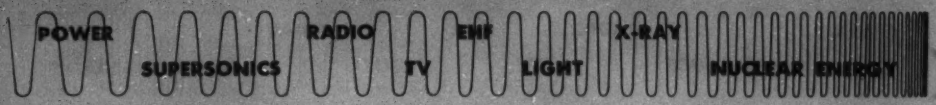
The Engineering Student Is an Individual

One of the great weaknesses of much present-day engineering education is that the student commonly is handled as a category rather than as an individual. Typically, a freshman is offered the choice of several fields of engineering, including possibly some options within an individual field. However, once his selection is made, the college catalogue all too often defines his entire 4-year education in detail, term by term, with pitifully few electives. It is, in fact, often possible for the freshman to predict with high reliability exactly what he will be doing Tuesday and Thursday at 9 o'clock in the spring term of his senior year and even to know the room in which he will be sitting at that time. This authoritarian method of training is supposed to turn out a graduate engineer who can analyze himself, plan his own future, exercise independent judgment, and assume responsibility easily and well.

It is time that each student be treated as an individual, and that consideration be given to his personal ambitions, his likes, his strong points, and his weaknesses. Each student needs an opportunity to do some experimentation with himself and his training, in order to obtain the experience and the data that will permit him to make a personal inventory.

It is true that the flexible curriculum makes it necessary for the student to think about his own qualifications—what he wants to do and what he expects to obtain from college—but this is hardly a disadvantage. A flexible curriculum also requires that the faculty adviser spend more time talking with each student about the latter's problems and goals, and that he do actual counselling rather than merely signing a study card that is copied out of the college catalogue. Again, this is not exactly to the student's disadvantage.

This discussion is thus concluded with the



thought that one of the most important steps which engineering education can take in the future is to arrange matters so that each student has the opportunity to tailor his curriculum to fit his personal characteristics, rather than being forced into a predetermined mold that is the same for all students. Lockstep may be all right for criminals, but it is not the best way to train engineers to take responsibility in the world of the future.

Thesis Projects in Magnetic Amplifiers

H. F. STORM
MEMBER AIEE

DURING A MEETING of the Theory Subcommittee of the AIEE Magnetic Amplifier Committee, the discussion dwelt on the problem of acquainting college students with magnetic amplifiers. It was felt that students who wish to deepen their knowledge in this field find it often difficult to do so, because of an apparent lack of suitable thesis projects. To remove this difficulty and, thereby, stimulate interest in studying this subject, the subcommittee members suggested a number of thesis projects which are believed to have:

1. High-academic content.
2. Practical importance.
3. Good probability for finding solution.

Such projects are listed in this article. To provide initial guidance to the students, the proponents of the thesis projects are identified at the end of the project list by the project number and may be contacted by the students. After completion of the thesis project, the student is requested to send one copy of the thesis to the proponent of his project, and another copy to the Chairman of the Theory Subcommittee.

Lists of Thesis Projects

1. Characteristics of 2-Phase Servo Motors, Driven from Magnetic Amplifiers. A number of magnetic-amplifier circuits have been developed for driving the control phase of 2-phase servo motors. Although some information has been published on the effect of various wave forms on the speed-torque characteristics of such motors, there is need for a good analytical and experimental treatment of this subject, covering the different types of circuits which are commonly employed for this purpose.

2. Circuit Comparisons. Study experimentally and/or theoretically the technique of applying biased rectifiers to increase the effective control circuit impedance in the half-wave bridge-type magnetic amplifier, as described in NAVORD Report No. 4258, March 29, 1956 (Fig. 1), e.g., compare the merits of this circuit with those of the Ramey circuit.

3. Computing Amplifier. Investigate the errors introduced by variations in supply voltage, frequency, and wave shape into computer circuits, operating on the principles outlined by Finzi and Mathias.[1]

Dynamic Properties (4 through 7).

4. Sampled-Data-System Analysis. Since the magnetic amplifier is basically a sampling device, the techniques that have been developed for sampled-data feedback systems should be applied to magnetic amplifiers. By so doing, the noncontinuous transforms (Z transforms) of the magnetic amplifier will be developed and can be applied to the determination of stability of the system in which the amplifier is incorporated.

5. Transfer Function of Magnetic Amplifiers. Many magnetic amplifiers exhibit a double-valued response, depending upon the direction of the control signal. In system analyses for servomechanisms, Nyquist and Bode diagrams are often used, but these methods cannot be directly applied where a double-valued response is present. The objective of this thesis project is to study the response (time constant, dead-time lag, etc.) of self-saturating magnetic amplifiers, having double-valued response, in order to arrive at a transfer function suitable for application in Nyquist or Bode diagrams.

6. Effect of Supply Frequency on Figure of Merit. Some preliminary statements have been made in the literature regarding the effect of supply frequency on figure of merit. Now that better information is available on magnetic-core characteristics and the influence on amplifier performance, a good analytical treatment of this subject may be possible. Such a treatment should take accurately into account the variation of core characteristics with frequency.

7. Bistable Circuit. In bistate magnetic-amplifier circuits, the switching time from OFF to ON and from ON to OFF appears to be a function of several variables, including the magnitude of signal and the amount of regeneration. An objective of this thesis project would be to study the factors influencing the switching time and to determine some appropriate criteria which would relate the ratio of power gain (switching ratio) and the switching time.

8. High-Frequency Operation. If a magnetic amplifier is operated from a high carrier frequency, its bandwidth may be made wide enough to accept low-frequency a-c signals without demodulation. The circuit may be designed to provide both voltage and power gain at the low frequency. An object of this thesis project would be to determine optimum coupling circuits to the load. Consideration should also be given to over-all circuit efficiency (ratio of high-frequency power supplied to low-frequency power output).

9. Interstage Coupling. If two magnetic amplifiers of the self-saturated type are grouped together to form a 2-stage magnetic amplifier, the ampere-turn gain of the 2-stage magnetic amplifier usually is less than the product of the gains of the two individual amplifiers. The object of this thesis project is to study the mechanism of gain reduction and to arrive at recommendations for reducing or eliminating the aforementioned gain reduction.

Low-Level Amplifiers (10 and 11).

10. Input-Stage Design. Work is needed on the design of control circuits and input stages of magnetic amplifiers operating at extremely low power levels. This work, to be effective, may require the redesign or origination of transducers that will generate the required signals and transfer them in optimum manner to the input stage. Work is also needed in the optimization of multi-stage amplifiers for best closed-loop dynamic performance.

11. Control Hysteresis. Make investigation of control-circuit hysteresis in second-

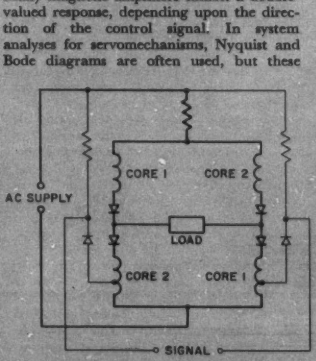
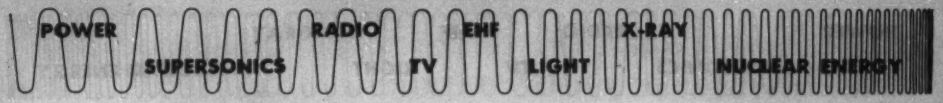


Fig. 1. Project 2, Circuit Comparisons.

A special article by the Theory Subcommittee of the AIEE Magnetic Amplifier Committee and recommended by the AIEE Committee on Education.

H. F. Storm is with the General Electric Company, Schenectady, N. Y.



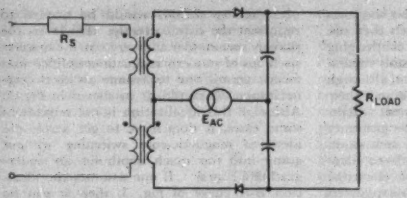


Fig. 2. Project 14, Doubler Circuit.

harmonic-type magnetic amplifier. In case sufficient material has been published already on this topic, a literature study alone may be useful.

12. Polyphase Amplifiers. More work (and published papers) is needed on the analysis of polyphase magnetic amplifiers. This work should explore the various types of polyphase circuits, the methods of connecting control windings, operation with various types of loads, and stability. Usable expressions for gain and time constant should be derived as functions of the core material, geometry, windings, and interconnection.

Prediction of Control Characteristics (13 through 16).

13. Relation between Control Characteristics and B-H Loop of Cores. Work should be continued on the prediction of the control characteristics of magnetic amplifiers from the measured curves of ϕ versus time with H as a parameter. Methods for determining such curves from the physics or the metallurgy of the material should be developed.

14. Doubler Circuit. A magnetic amplifier circuit which exhibits many interesting characteristics including high power gain, well-filtered output, and high output voltage is shown in Fig. 2. No attempt has yet been made to analyze this circuit in order to predict its mode of operation and determine design equations for its performance. Thus, the object of this thesis project would be to analyze the circuit behavior and establish design equations.

15. Amplifier with Counter-Emf Load. It is felt that a theory is needed for the self-saturated magnetic amplifier working into a counter-emf load, such as a storage battery or the armature of a d-c motor. Such a theory should be aimed to produce design information and, therefore, its findings and conclusions should be presented in a manner which can be easily grasped and utilized.

16. Effects of Winding Capacitances. How are the three basic magnetic-amplifier circuits, namely "doubler," bridge, and center-tap, influenced, favorably or unfavorably, by capacitance in the windings of the coils? To what extent do these effects depend on the properties of the core material? At which frequencies do capacitance effects become appreciable? One way to determine winding capacitances would be to measure capacitance of coils wound on non-magnetic core forms.

17. Push-Pull Circuits. To study the various conventional single-stage push-pull a-c and/or d-c output magnetic amplifiers with a view to determining the optimum methods of mixing the two single-ended outputs and the effect of bias and control circuit configuration on jumps or discontinuities in the transfer curve, when a low-frequency sinusoidal signal is applied.

18. Stability of Amplifiers. There is need for an analytical and experimental comparison of the stability of various magnetic-amplifier circuits with respect to changes in core and rectifier characteristics. The result of a project such as this should be a quantitative comparison of the drift and gain stability of various types of magnetic-amplifier circuits, including various types of feedback, assuming comparable changes in core and rectifier characteristics in all cases.

19. Stabilizing of Closed-Loop Systems. The area of stabilizing methods for feedback systems incorporating magnetic amplifiers needs considerable work. Both the specific techniques and the analytical methods for predicting the performance of the stabilized system need attention.

Project Number	Proponents and Addresses
1, 6, 18	R. A. Ramey, Westinghouse Electric Corporation, Engineering Center, East Pittsburgh, Pa.
2, 16	J. J. Suozzi, Bell Telephone Laboratories Inc., Whippany Road, Whippany, N. J.
3, 11	T. G. Blanchard, R. J. Distler, Bell Telephone Laboratories Inc., Whippany Road, Whippany, N. J.
4, 10, 12, 13, 19	A. Kusko, Massachusetts Institute of Technology, Room 10-150, Cambridge, Mass.
5, 9, 15	H. F. Storm, General Electric Company, 1 River Road, Building 37, Schenectady, N. Y.
7, 8, 14	D. Feldman, Bell Telephone Laboratories Inc., Whippany Road., Whippany, N. J.
17	T. G. Wilson, Magnetics Inc., Butler, Pa.

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Magnetic Amplifiers Serve To Teach Power Modulators

H. C. BOURNE
MEMBER AIEE

R. M. SAUNDERS
MEMBER AIEE

MAGNETIC AMPLIFIERS are an example of a whole group of devices having common characteristics and being amenable to a common method of analysis. The common characteristics of this class of equipment are that they control and modulate the flow of power and energy and are mechanically static. This article describes a method of analyzing such static power modulators by applying the techniques to magnetic amplifiers in particular.

These methods, relying as they do upon the knowledge of circuit analysis at the command of an advanced student, make it possible for an undergraduate student to gain considerable insight into nonlinear magnetic circuit analysis, as well as provide him with tools for exploiting more complicated situations in the future.

Fig. 1 shows a block into which a signal bearing intelligence is injected; it is desired that the signal modulate the flow of power from the source into the load in accordance with that signal. Actually, the general power modulator of Fig. 1 may involve mechanical motion if any of the terminals involve mechanical displacement or velocity, such as in d-c and a-c motors. Fig. 1 may also represent a stationary power modulator, where all inputs and outputs are the same

Full text of conference paper presented before a session of the AIEE Committee on Magnetic Amplifiers, AIEE Summer and Pacific Meeting, San Francisco, Calif., June 25–29, 1956.

H. C. Bourne and R. M. Saunders are with the University of California, Berkeley, Calif.

(electrical, in this case). As a general rule, stationary power modulators control the flow of energy by means of a nonlinear material or medium when the terminals are associated with an electric network. The authors cannot offer a general proof of this statement, but can think of no exceptions.

Not only do magnetic amplifiers fit this hypothesis, but so also do dielectric amplifiers, hot-pool-cathode gaseous tubes, relays, and switching transistors. Hence, the techniques for solving problems involving magnetic amplifiers also apply to these other

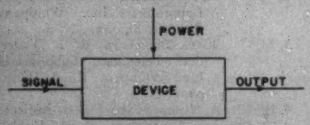


Fig. 1. Generalized power modulator

classes of equipment and the procedures described here have a universal application. The reason for choosing to deal with magnetic amplifiers as the example is that, of the several stationary power modulators enumerated, the magnetic amplifier is the most difficult with which to work because of the integration aspect, as will be discussed. The authors attempt to impress upon the student that the methods used on magnetic amplifiers work equally well on other stationary power modulators.

Aside from these general aspects, magnetic amplifiers play an increasingly important part in modern electrical technology, so that an undergraduate curriculum in electrical engineering should treat these devices for purposes of illustrating the fundamentals of coupled circuits with a nonlinear coupling medium. Magnetic amplifiers provide a logical bridge between the transformer and the rotating power modulator. Ideas concerning gain and dynamic response can be introduced before the complexity of a new degree of freedom, or mechanical motion, is encountered. Ideas concerning the system concept, the matching of control to load, and the over-all system behavior can be illustrated more easily.

In the classroom, one of the primary objectives is to provide motivation for the student. The magnetic amplifier provides the motivation always associated with relatively new and popular devices. The vacuum tube, telephone, radio, radar, and microwave techniques all have served or are serving this same purpose. Rotating machines served this purpose many years ago. This aspect is of some importance since piecewise-linear systems, Faraday's Law, and the exploitation of magnetic materials may be illustrated by other means, although probably not in such a neat package as available with magnetic-amplifier circuits.

On a more advanced level these relatively new circuits and devices provide excellent motivation for graduate level instruction and research. A study in some detail of the components and the systems in which they are used presents fundamental and challenging problems. However, it is probably necessary to emphasize at this point, that, although the study of magnetic amplifiers and their associated systems to some extent might serve as ends in themselves at the graduate level, at the undergraduate level such study serves only as a means to an end—to illustrate the fundamental laws of electrical engineering. There should be no plan to raise the magnetific amplifier to the exalted position occupied for so long by the transformer, although there is perhaps more excuse to do so because of the additional and more complex theories involved.

Irrespective of the reasons for the teaching of magnetic amplifiers, educators should not lose sight of the main objective: the magnetic amplifier is but one example of a large class of stationary power modulators exploiting a nonlinear material or medium.

Piecewise-Linear Circuits with Switching

Piecewise-linear circuits are not altogether new. Many authors have contributed to the literature of switching circuits, particularly in connection with logical operations. In power circuits, Mason and Zimmermann in a forthcoming book use this method extensively for the analysis of electron-tube circuits. Martin[1] also employs this method and applies it to some electronic and magnetic-amplifier circuits. The authors, however, are urging general acceptance of this method for handling all electric stationary power modulators.

Circuits, that are linear between two limits and then switch to a new mode of operation when some criterion is reached, provide the central core of the analysis of stationary power modulators. A relay is a simple example of this idea. A relay stays open until a critical current in the coil causes the contacts to close; circuitwise this would be represented by a single switch with a switching criterion of i_c as shown in Fig. 2.

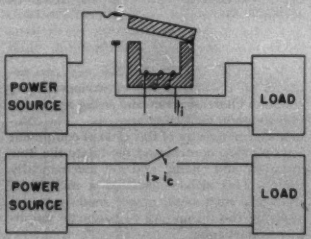


Fig. 2. Actual and piecewise linear circuit for a relay acting as a power modulator.

In an analogous fashion, magnetic cores and the windings on the core may be represented as a piecewise-linear circuit. Inasmuch as the magnetization curve of the core is a continuous function, an infinite number of switching circuits would be needed to represent the core correctly. However, the sharply rectangular and very narrow hysteresis loops of modern magnetic-amplifier materials permit one to assume an ideal magnetization characteristic as shown in Fig. 3. Although this idealization is not tenable in some cases, it does serve to get across the ideas of magnetic-core switching without going into too much depth for an undergraduate course. If one assumes the idealized *B-H* curve of Fig. 3, then it can be shown that a 2-winding core has the switching circuit of Fig. 4 when leakage inductances are neglected. The switch closes when the flux reaches saturation in either direction and opens when $\Sigma Ni=0$. In a similar manner, rectifiers may be shown as ideal components, as in Fig. 5. The switch closes when $e_r<0$ and opens when $i_r<0$.

Having the equivalent switching circuit for the core and rectifiers permits the formulation of a switching circuit to represent any magnetic-amplifier configuration. For example, the single-core magnetic amplifier of Fig. 6(A) has the switching circuit of Fig. 6(B).

The first step in the analysis of this piecewise-linear circuit is to write the equations and switching criteria describing the different modes of operation:

Mode A—Core Unsaturated (S_1 open):

From the core characteristic: $\Sigma Ni = Ni_L + i_c = 0$

Consequently: $Ni_L = -i_c$

Further from the rectifier constraints, since neither current may be negative: $Ni_L = -i_c = 0$

Submode *A 1:* If $e_s > Ne_c$ (S_2 open, S_3 closed), then $e_1 = e_s$

Submode *A 2:* If $e_s < Ne_c$ (S_2 closed, S_3 open), then $e_1 = Ne_c$

Mode B—Core Saturated (S_1 closed):

If $e_s > 0$ (S_2 closed), then $i_L = e_s/R_L$

If $e_s < 0$ (S_2 open), then $i_L = 0$

If $Ne_c > 0$ (S_3 closed), then $i_c = e_c/R_c$

If $Ne_c < 0$ (S_3 open), then $i_c = 0$

From the equations describing the possible modes, the operation is defined if the excitations are known. The switching criteria are automatically defined in the title of the modes. However, the importance of the core switching criteria merits some further comments. If the core is unsaturated, monitoring the ΣNi gives little useful information because it is everywhere zero. On the other hand, monitoring the core voltage e_1 gives a dynamic picture of the operating point according to Faraday's Law $N\dot{\phi} = e_1$ or $N\phi = \int e_1 dt$, which introduces the most important concept of the voltage-time integral "absorbed" by the core. If the core is saturated, e_1 is everywhere zero but monitoring the ΣNi gives the dynamic picture of the operating point. In abbreviated form the useful switching criteria are: Switch closes when $\int e_1 dt$ brings ϕ to $|\phi_s|$ and switch opens when ΣNi becomes zero. Of course, further

checks must be made to make sure that the piecewise-linear system makes the proper excursion after the switching occurs. Exactly the same reasoning concerning the monitoring of the rectifier voltage and current may be applied to obtain the rectifier switching criteria.

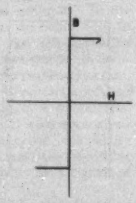


Fig. 3. Idealized B-H curve for magnetic amplifiers.

The excitation functions may be introduced, and as typical examples $e_s = (\pi/2)E_s \sin \omega t$ and $e_c = (\pi/2)E_c|\sin \omega t|$ are chosen as shown in Fig. 7. The amplitudes of these excitations are expressed in this form because average valves are usually of most interest. Although e_c could be taken as a direct current with no additional difficulty insofar as a graphic picture of the operation is concerned, the analytic expressions become transcendental and the additional complexity serves no particularly useful purpose.

The operation is now deduced from Figs. 7 through 9, using the previously stated modal equations. The time plot and the piecewise-linear magnetization curve themselves form useful adjuncts to the switching circuit and the modal equation as tools in the analysis. The very process of tracing the operation in time and on the B-H curve often provides exactly the insight needed to determine the dynamic operation. Examination of Fig. 7 in conjunction with the modal equations

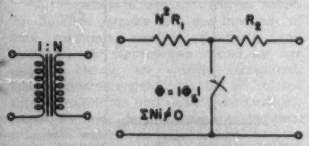


Fig. 4. Two-winding saturable reactor and its equivalent switching circuit with criteria shown for switch closed.

shows that, if the core is unsaturated, e_1 equals Ne_c in the first half cycle and e_s or Ne_c in the second depending on which is larger. In any case, for the values shown, the voltage across the core is always positive. Whether the operation is started with the core unsaturated (Mode A) or not, this mode cannot long exist, and the circuit operates in the steady state with the core saturated (Mode B). The corresponding currents are shown in Fig. 8. The half-cycle average of the current in the load resistance is independent of E_c and thus equal to the quantity E_s divided by R_L.

As E_c is allowed to assume negative values, the more interesting modes appear. Fig. 9 illustrates operation in the useful amplifier region. The very important and basic concept to notice here is the possibility of resetting the core by the control voltage Ne_c, the voltage-time area being represented by the shaded area in the first half cycle. Starting on the vertical portion of the B-H loop at $\omega t = 0$ (voltages are zero and, since there is no stored energy, the currents are zero), steady-state operation is quickly obtained after one cycle to be that shown in the figure. For larger values of $|NE_c|$ until $|NE_c| = E_s$, the operation remains essentially the same assuming that the core can absorb the volt-time integral associated with e_s, i.e., $2N_\sigma\phi_\sigma \geq \int_0^\pi e_s dt$. In fact, this volt-time integral is used as the design criteria for this particular illustration. Note that the shaded area in the second half-cycle is equal to that in the first half-cycle and that the modal sequence is $A(1)$, $A(2)$, B, and repeat.

For values of $|NE_c| > E_s$, $e_1 = e_s$ in both half cycles, the core stays unsaturated, and the currents are zero.

The circuit operation is now completely determined for all values of Ne_c.

Difference Equation and Transfer Function

The dynamic behavior of the nonlinear magnetic circuit has been completely described by the time plots in Fig. 7 through 9.

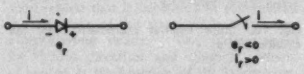


Fig. 5. Ideal rectifier and its switching circuit with criteria for switch closing.

However, the concepts of transfer function, gain, and time response may be introduced more effectively if these results are expressed in analytic form. From Fig. 9, the firing angle α is determined such that the flux excursion in the second, or load, half-cycle, $(n+1)$th is equal to the flux excursion in the first or reset half-cycle, nth. Expressing this fundamental fact in equation form

$$NE_c(n) + E_s\left[\frac{1-\cos\alpha(n+1)}{2}\right] = 0 \qquad -E_s < NE_c < 0 \quad (1)$$

The terms in the equation represent the shaded volt-time areas divided by a common factor π. Equations of this type are called the determining equation and are used most effectively by Johannessen[3] in more complicated circuits.

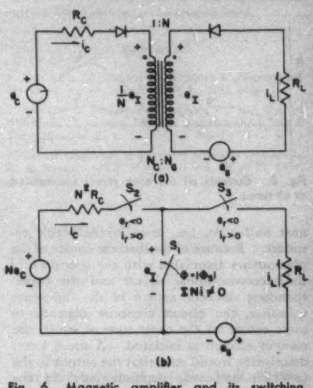


Fig. 6. Magnetic amplifier and its switching circuit. In this example the winding resistances are included in R_c and R_L.

Solution of equation 1 for $\cos\alpha(n+1)$ yields

$$\cos\alpha(n+1) = 1 + \frac{2NE_c}{E_s} \quad (2)$$

which expresses the firing angle as a function of control voltage.

The half-cycle average output in the load half-cycle is

$$E_L(n+1) = E_s\left[\frac{1+\cos\alpha(n+1)}{2}\right] \quad (3)$$

and substitution from equation 2 gives the transfer characteristic expressed in the form of a difference equation

$$E_L(n+1) = E_s + NE_c(n) \qquad -E_s < NE_c < 0 \quad (4)$$

Equation 4 describes the useful amplifier region which, combined with the conclusions

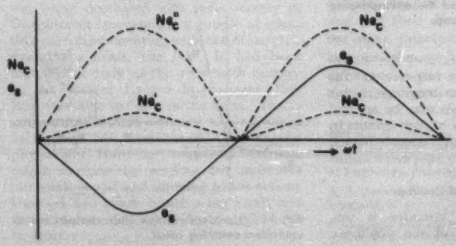


Fig. 7. Excitation functions for the magnetic amplifier of Fig. 6, showing two particular values of Ne_c.

drawn concerning operation for larger and smaller NE_s, gives the static transfer characteristic of Fig. 10.

The time response of the magnetic amplifier is ascertained from equation 4. A change in the control input in the nth half-cycle results in a complete response of the output in the

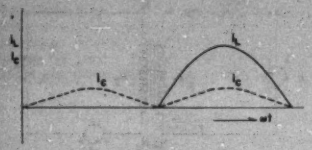


Fig. 8. Currents of the core remains saturated at all times.

next half-cycle, i.e., so-called half-cycle response. Because of the discrete nature of the phenomena associated with the operation of the piecewise-linear circuit and the corresponding discrete nature of the difference equation, the circuit response depends to some extent on the exact time at which the control change is initiated. A more exact description would state that the output in the $(n+1)$th half-cycle depends only on the control in the nth half-cycle.

The voltage gain K_v of this elementary circuit corresponds to the turns ratio: $K_v = N = N_0/N_c$. Because ideally no control current flows, the power gain is infinite, but this is a result of the assumptions concerning ideal cores and rectifiers.

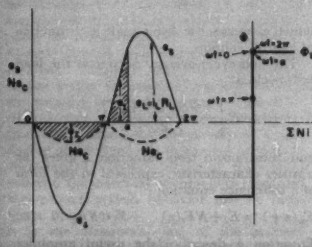


Fig. 9. Volt-time areas contributed by the control and output circuits and the corresponding operating points on the B-H loop.

The difference equation and the corresponding gains and time response of this single-core piecewise-linear magnetic circuit is typical, and this analysis may be applied generally to a wide variety of such circuits to illustrate the fundamental concepts which have been introduced.

Nonideal Cores and Rectifiers

As magnetic-amplifier circuitry is improved, the exploitation of the nonlinear properties of core materials and rectifiers becomes inherently limited by the deviations of the materials themselves from the ideal. It is the limitations imposed by the materials which these magnetic circuits illustrate in such a clear and basic fashion. The nonideal rectifier characteristic of Fig. 11 may be introduced and represented analytically by forward and backward resistances. Circuits in which these resistances play an important role are analyzed to illustrate the interplay between fields, materials, and circuitry in producing useful devices. Fig. 12 is an example of such a circuit in which the rectifier back resistance and the variable control resistance determine the amount of the core reset.

The analysis of Fig. 12 proceeds in the same manner as before, resulting in the

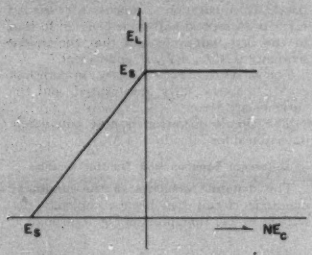


Fig. 10. Static transfer characteristic for the circuit of Fig. 6.

following expression for the half-cycle average output

$$E_L = \frac{R_L}{R_L+R_f}\,\frac{R_b-R_f}{N^2R_c+R_L+R_b}\,E_s \qquad (5)$$

$$E_L = \frac{R_L}{R_L+R_f}\,\frac{R_b}{N^2R_c+R_b}\,E_s \quad \text{if } R_b \gg R_f, R_L \qquad (5a)$$

If R_c is made sensitive to rotational or translational position then the device produces an electrical signal which is a function of this position.

Introduction of the nonideal core of Fig. 13 complicates the analysis because of the

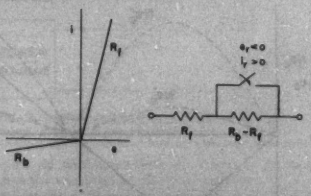


Fig. 11. Nonideal rectifier characteristic and its equivalent switching circuit.

multivalued nature of the practical magnetic-amplifier square-loop core materials. However, again the magnetic-amplifier switching circuits provide an excellent illustration of this important type of multivalued nonlinearity. The single-core Ramey circuit shown in Fig. 14 furnishes an example

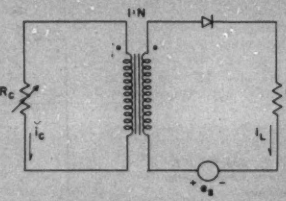


Fig. 12. Magnetic amplifier where the control is effected by a resistor rather than a voltage as in Fig. 6.

which emphasizes these concepts. The analysis of this circuit has been presented[3] and will not be repeated here.

At this stage, the magnetic-amplifier circuits permit the introduction of the following important concepts: (1) the operation of piecewise-linear systems, (2) the operation of piecewise-linear systems with multivalued nonlinearities, (3) a dynamic

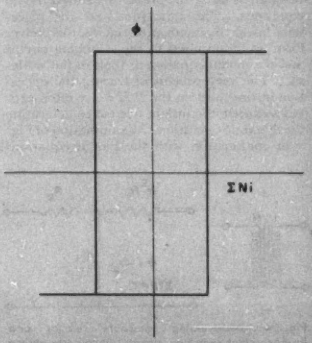
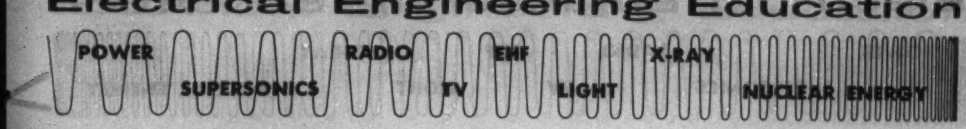


Fig. 13. Nonideal core characteristic.

transfer function including gain and time response, and (4) difference equations as distinguished from differential equations.

Complicated Circuits and Difference Equations

Although all of the important concepts may be illustrated by single-core circuits, more complexity in the analysis and the resultant difference equations may be achieved by using double-core circuits. It should be remembered, however, that the



primary purpose is not to make a magnetic-amplifier designer out of an undergraduate student, but only to teach fundamental scientific principles on which the future exploitation of nonlinear magnetic and rectifier materials may be based.

The series-connected saturable reactor, which has been extensively analyzed in the literature, serves as an example. At the undergraduate level, it is probably wise to tread lightly as far as the self-saturating magnetic amplifiers are concerned. A completely satisfactory dynamic transfer function, including core and rectifier imperfections and valid for a wide range of parameters, has yet to appear. Even if such an analysis were available, the inherent complexity would probably tend to start the inevitable decrease in the ratio of new ideas explained per unit time.

These double-core circuits are described

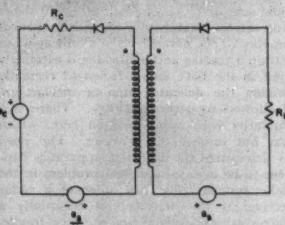


Fig. 14. Single-core Ramey circuit.

in general by a difference equation of the form

$$E_L(n+1)=K_1E_c(n)+K_2E_c(n+1)+K_3E_L(n)+K_4 \quad (6)$$

The constants K assume different values for different circuits and are functions of core materials, rectifier materials, and circuitry; the appropriate values for our original circuit are readily recognized. Ideas concerning stability which are related to the magnitude and sign of the feedback factor K_3 and ideas concerning the time response which are also related to the feedback factor may be discussed. For instance, equation 6 reduces to equation 7 for the series-connected saturable reactor

$$E_L(n+1)=K_1[E_c(n)+E_c(n+1)]+K_3E_L(n)+K_4 \quad (7)$$

in order for the equation to represent a stable system $K_3 < 1$. For a step function input the number of half cycles necessary for 63 per cent of the resultant output change to occur is $-1/\log_e K_3$. The steady-state gain is $K_1/1-K_3$. If $K_3 \cong 1$, then an approximation that may be thought of as the time constant may be defined as $\tau = \pi/\omega\log_e K_3 \cong \pi/\omega(1-K_3)$, and an approximate transfer function may be defined in operational form

$$\frac{E_L(s)}{E_c(s)}=\frac{K_1}{1-K_3}\,\frac{1}{1+\frac{\pi}{\omega}\frac{1}{1-K_3}s}$$

A gain-bandwith product of $K_3/\tau = \omega K_1/\pi$ is another concept that may be introduced. This discussion just points out a few of the additional points that may be touched on as a result of the study of the nonlinear magnetic-amplifier circuits.

Conclusions

From actual teaching experience the authors conclude that: (1) It is possible to teach the undergraduate the theory of generalized power modulators, if piecewise-linear circuit techniques are used; (2) Magnetic-amplifier circuits serve admirably to illustrate stationary power modulators; (3) Study of magnetic amplifiers serves as a powerful motivation for original thinking on the part of the student; and (4) Magnetic amplifier studies tend to integrate previous circuit theory and permit the student to extend his thinking to the system level.

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Bats and Radar

A. J. PENNINGTON
STUDENT MEMBER AIEE

THE WORD "RADAR," as most engineering students already know, came into the language only a few years ago. During the early days of World War II, it was actually classified a military secret for the good reason that it explained in some detail the operation of this strategically important object-sensing device. The letters stand for "radio direction and ranging" which, of course, is the function of the instrument. In addition, the word is a palindrome which means it is spelled the same way forwards and backwards. In this way, it describes radar's principle of operation: a high-frequency radio wave bounced directionally off a target yields the angle and distance information necessary to locate an object completely in space.

Radar is without a doubt the most powerful weapon of defense ever invented. It turned the tide of the air war against Germany and, today, is the basic component in our continental defense system.

Bat Radar

At about the same time that military radar was being developed with great secrecy in Government laboratories, a couple of scientists were experimenting with one of nature's strangest animals, the bat. It had been observed as early as the eighteenth century by an Italian, Lazaro Spallanzani, that bats were able to "see" in the dark. It was not until 1920 that a theory was advanced to explain this phenomenon. An English physiologist, Hartridge, suggested that they might navigate by sending out pulses of ultrasonic sound and listening to the echoes. Humans had never heard a bat's call and the ultrasonic idea would explain this much at least.

In 1938, a Cornell zoologist, D. R. Griffin, took some bats to a Harvard physics laboratory which owned a receiver for ultrasonic sound. In those days ultrasonics was a relatively unknown field and the whole experiment must have seemed very mysterious. With the receiver, however, Griffin actually found the high-frequency pulses which had been predicted by Hartridge. Their frequency was about 50,000 cycles per second (cps), much higher than the human limit of 20,000 cps. He then tested the bat's object avoiding ability in the following way: a network of wires was hung vertically in a testing room and the bats were made to fly blind through the maze. The wires were of various sizes, and it was found that the animals almost never collided with ones 3/16 of an inch or greater in diameter. Their skill decreased rapidly for smaller ones.

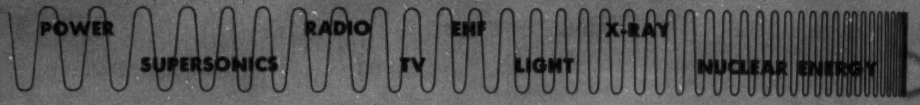
Further experiments showed that the bats lost practically all their ability when one ear was stopped. The inference from this was that their directional sense worked on the same principle as binocular vision in humans, the slight phase and amplitude difference in the second reaching each ear, indicating direction.

Full text of First Prize Student Paper, which won the award for papers presented at the AIEE District 2 Student Branch paper competition at Carnegie Institute of Technology, Pittsburgh, Pa., April 27, 1956.

A. J. Pennington is a student at Princeton University, Princeton, N. J.

Photographs were made available through the courtesy of Prof. D. R. Griffin of Harvard Biological Laboratory.

Electrical Engineering Education



Frequency-Modulation Characteristic

The war halted these studies temporarily, but later Professor Griffin made a much more detailed investigation of the bat's object-sensing apparatus. He found it had some rather unusual properties. First among them was the fact that the ultrasonic

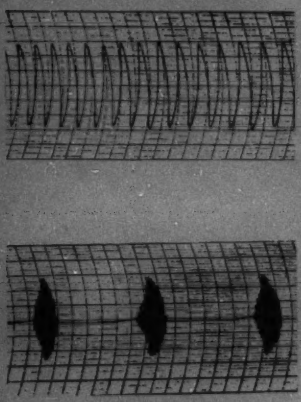


Fig. 1 (top). Diagram of bat pulse series. (bottom). Expanded single pulse showing frequency-modulation characteristic.

call is frequency modulated, that is, it changes pitch from beginning to end. Of the hundred or so individual waves that make up the 2-millisecond call, the first few have a frequency of about 100,000 cps. By the end of the signal the frequency has dropped to about 40,000 cps. This is a very important property and explains why the bats were able to navigate so successfully in the small distances of the test. To see why, suppose for a moment there were no frequency modulation. The bat would emit a cry of constant pitch for 2 milliseconds; the speed of sound in air is roughly 1,130 feet per second or 1.13 feet per millisecond. In the 2 milliseconds of the pulse, then, the cry would have traveled over 2

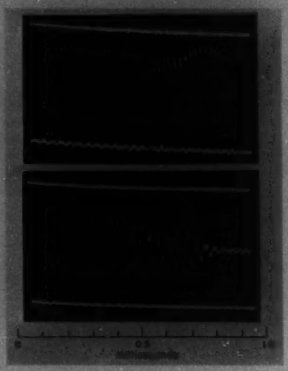


Fig. 3. Beginning and end of a single pulse taken with expanded sweep. Note frequency shift.

feet. The sound must go out and back, so if the bat is within a foot of an object he will still be transmitting when the first waves of the echo strike his ear. Under these conditions he will smash head on into anything nearer than a foot when he emits the call. Here is where frequency modulation comes in. Since the first waves are at a high pitch, he is able to distinguish them from later ones which have dropped in frequency. The range is more than two octaves, so he can detect the change without trouble.

Figs. 1 and 3 show this frequency-modulation characteristic very clearly. The other illustrations show some typical bat pulses. It will be noticed that there is a small a-f component in most of the pulses; it is most pronounced in younger bats. Fig. 4 shows the frequency response of the acoustical system used in the measurements.

Radar Analogue: TR System

This is a good point at which to return to our starting point, the radar system, and look at it a little more closely. The oscillograms show that the intensity of the ultrasonic components of the bat call is of the order of 10 to 20 dynes per square centimeter The measurements were taken several meters away from the animals; the intensity up close actually reaches about 60 or 70 dynes per square centimeter. This corresponds roughly to the sound level in a subway when a train is passing and, naturally, is extremely loud in the bat's ears. It would certainly deaden the delicate listening mechanism, if allowed to enter full force. There is a similarity with radar location here, which was not immediately obvious. The need to desensitize the listening apparatus happens to be a very important problem in the radar system. The first stage of a radar receiver is the detector; it is usually a silicon crystal and, therefore, very fragile. The first full burst of the transmitted pulse, if unchecked, would clearly ruin it. This common problem of bats and radar also has a common solution. In the bat, a large muscle in the auditory passage contracts to block the intense sound during transmission. Apparently it is a reflex,

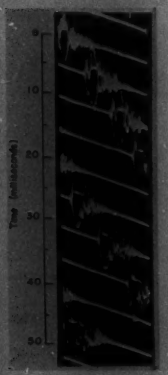


Fig. 2. Pulse series during active pursuit of an artificial target.

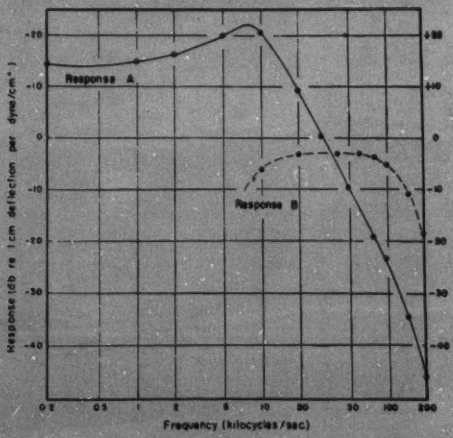
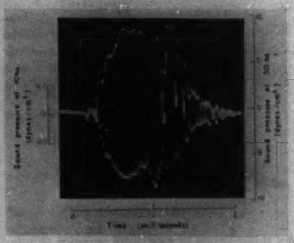


Fig. 4. Frequency response curves of acoustical system.

that is, an automatic action. In radar, a device called a "TR" or "Transmit-Receive" tube is used. This simply is an arc-type switching device which, in conjunction with the wave guide, automatically causes the receiver to appear as a very high impedance when the transmitter is firing.

Radar Analogue: Range Resolution

Returning now to the bat's difficulties with objects at close distances, it is seen that their system has another problem in common with radar. The minimum possible range for radar is determined by the duration of its transmitted pulse. This is a crucial limitation in wartime if one wants to know whether an enemy periscope has bobbed up a few hundred feet from the ship. It is also an irreducible limitation as long as a fixed minimum pulse width is required and electromagnetic energy is bounced off the targets. With frequency modulation, however, as discussed earlier, the resolution could be increased at will. Frequency-modulated radar was actually tried in the early days, but it proved a little impractical when extremely high frequencies came into use. Unfortunately, no method could be developed to frequency modulate in the microwave region.



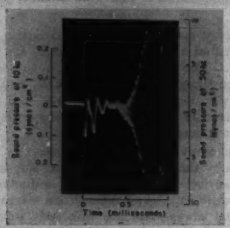


Fig. 5 (top). Typical pulse of an adult bat. Note audio component at beginning. Frequency response "A." Fig. 6 (bottom). Pulse of a half-grown bat. Frequency response "A."

Radar Analogue: Object Resolution

There is one important characteristic of the bat's cry that has not been mentioned as yet. It is wave length, the distance between individual crests of the signal. This quantity is related to frequency by the formula: $l = v/f$; where l is wavelength, v is velocity of propagation, and f is frequency. Its magnitude determines the smallest object that a bat (or a radar set) will be able to detect. If the dimensions of the target are comparable to wave length, the signal will simply flow around the object instead of being reflected. This is why audible sound travels around corners instead of casting a shadow as shorter wavelength light does. It also explains why bats necessarily use ultrasonic rather than audible sound. Even at its top frequency, the wave length of the bat signal is only 1,130 feet per second (the speed of sound in air) divided by 100,000 or 0.013 feet. This is 0.156 inch or about 3/20ths of an inch. It is easy to see why the bat performed so poorly on wires smaller than 3/16 of an inch.

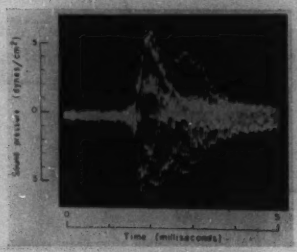


Fig. 7. Pulse of a very young bat. Frequency response "B." Note amplitude modulation.

Radio waves, of course, are propagated in quite a different way from sound waves, and also travel at a much higher speed, i.e., the speed of light. During the early part of the war, radar frequencies were high enough to pick up ships and aircraft; it was not until some years later that microwave technique extended the possibilities to periscopes and even smaller objects. Here again was a common problem and a common solution. As it turns out, bats have a much greater object resolution than radar, since the wave length of their signal is only about 0.6 centimeter compared with about 3 centimeters for most radars. This, of course, is because bats not only navigate, but also hunt with their "radar" and, therefore, must locate extremely small objects, such as insects.

Importance of the Analogy

What, may be asked, does all this amount to? Perhaps nothing. Or perhaps a great deal. The closeness in time between the discovery of "bat radar" and the military version may have been coincidental. It is true that Professor Griffin's work was not published until after radar was being used operationally. Still there is a possibility that the applied science of engineering took a clue here from the pure science of biology, perhaps from Hartridge's speculations. In this discussion, there have been shown enough important similarities between the two systems to arouse a little wonder, at least. After all, a creative idea may often exist in an unrecognized form for many years before being utilized. Perhaps the pressure of the German Luftwaffe early in the war was sufficient to call forth the latent idea of radar from biology. At any rate, there is no reason why it could not have happened.

A Pulse Generator Using Nonlinear Magnetic Cores

W. B. BRIDGES
STUDENT MEMBER AIEE

INCREASING EMPHASIS on the reliability of the components used in electronic equipment has resulted in the increased use of solid-state devices such as transistors and nonlinear magnetic cores. These devices have been used to replace limited life items, such as hydrogen thyratrons, electron tubes, etc. The pulse generator presented here is an example of the application of nonlinear magnetic cores to improve the reliability of a radar system modulator.

These radar modulators provide short-duration, high-voltage, high-current pulses to the magnetron which generates microwaves for the system. The essential function of the modulator, then, is to switch a high-voltage, high-current source intermittently across a load. In a typical system, pulse voltages and currents of the order of 30,000 volts at 30 amperes would be encountered for a duration of one microsecond or less. The pulse repetition rate might be a thousand pulses per second.

Text of the paper awarded first prize in the District 8 Student Prize Paper Contest.

W. B. Bridges is a student at the University of California, Berkeley, Calif.

This type of service results in unfavorable working conditions for electronic devices such as hydrogen thyratrons and, consequently, reduces their reliability.

History

About 1942, a pulse modulator circuit using a single nonlinear magnetic core was developed by E. Peterson and his associate at Bell Telephone Laboratories.[1] This device was used in many early fire-control radar systems. Its extreme ruggedness was a valuable asset as the radar sets were mounted directly on the naval guns they controlled. An inherent disadvantage was its rather low efficiency, which led to its replacement in later years by the hydrogen thyratron switched modulators.

As radar circuits began to use higher and higher powers for extended-range early warning systems, the reliability of the thyratron modulators diminished drastically. About 1950, W. S. Melville developed a multistage modulator using nonlinear cores.[2] This type of pulse generator does not have the inherent disadvantages of the earlier single-core types and currently is under extensive development.[3,4] It is this circuit that is presented here.

Nomenclature

A = Cross-sectional area of toroidal core: a point
A_k = Cross-sectional area of kth toroidal core
B = Flux density; a point
B_r = Saturation flux density of material
C = Capacitance; a point
C_k = Capacitance of kth capacitor
E = Voltage
e = Instantaneous voltage
E_g = Magnitude of input source voltage
$e_g(t)$ = Input source voltage
f = Frequency
H = Magnetizing force
H_c = Coercive magnetizing force
I = Current
k = Number of the general stage or component
L = Inductance
L_k = Inductance of kth inductor
L_{sk} = Saturated inductance of kth inductor
N = Number of turns
n = A number denoting the output stage or component
N_k = Number of turns on kth core
P_{pk} = Peak power of a magnetron
R = Resistance
t = Time
t_k = Time of saturation of kth inductor
v = Instantaneous voltage
v_k = Instantaneous voltage across kth capacitor
V_{pk} = Peak voltage of a magnetron
Δ = An increment
ϕ = Flux
ϕ_s = Saturation flux
ω = Angular frequency
ω_s = Angular frequency of the source

Switching Circuit

Like many other nonlinear devices, this pulse generator does not lend itself readily to direct mathematical analysis. A much easier and at the same time more enlightening mode of attack is by means of the so-called switching-circuit representation.

Essentially, the nonlinear characteristics of components are replaced with piecewise linear characteristics. For example, the nonlinear resistance of Fig. 1(A) could be replaced with the switching circuit shown in Fig. 1(B). The switch, of course, must be told when to open and close in order to insure proper operation of the analogue.

The general circuit for the pulse generator is shown in Fig. 2. It has an iterated structure very similar to a lumped delay line, except that all inductances after L_0 are nonlinear. The source, $e_g(t)$ is a sinusoidal voltage source with magnitude E_g and frequency ω_g. The load is shown here as a resistance and represents the first approximation to a magnetron load.

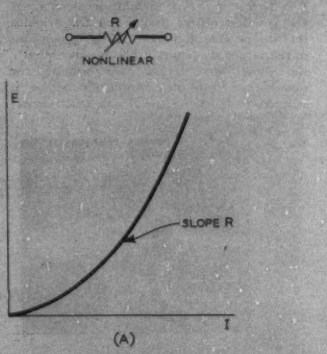


Fig. 1. (A) E–I characteristic of nonlinear resistor. (B) E–I characteristic of equivalent switching circuit.

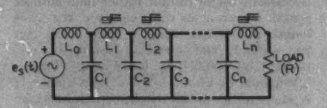


Fig. 2. Pulse generator, general circuit.

The equivalent switching circuit is suggested by the B–H characteristics of material used as cores for the nonlinear inductances, as shown in Fig. 3(A). When wound in toroidal cores, modern materials such as Orthonol, Permalloy, or Supermalloy have sufficiently high unsaturated permeability, low coercive force, and sharp saturation to justify the approximation shown in Fig. 3(B). An equivalent switching circuit having the B–H characteristic of Fig. 3(B) is shown in Fig. 4. Using this approximation,

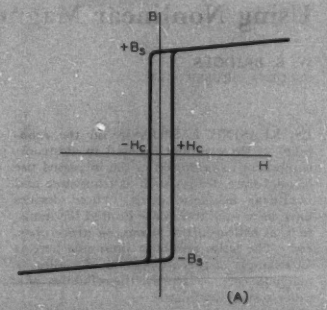


Fig. 3. (A) B–H characteristic of Deltamax, Orthonol, Permalloy, etc. (B) Idealized B–H characteristic of core material.

the general circuit (Fig. 2) can be redrawn as in Fig. 5.

The question arises: "When do the switches open and close?" The answer to this is found by noting that the voltage induced in a coil is proportional to the time rate of change of flux.

$$e = N\frac{d\phi}{dt} \qquad (1)$$

Fig. 4. Development of equivalent switching circuit considering Fig. 3. (A) Inductance with nonlinear core. (B) Approximation showing very large unsaturated inductance. (C) Practical approximation.

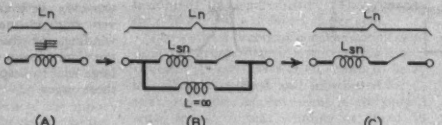
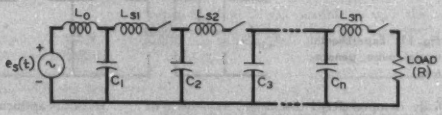


Fig. 5. Pulse generator switching circuit equivalent of Fig. 2.



rearranging,

$$d\phi = \frac{1}{N}\, e\, dt \qquad (2)$$

or

$$\Delta\phi = \frac{1}{N}\int_0^t e\, dt \qquad (3)$$

That is, the change in flux is proportional to the time integral of the voltage, or, graphically, the area under the applied voltage curve. The maximum flux change that can occur is $2\phi_s$, twice the saturation flux.

Suppose the flux in a given core is at point A in Fig. 6. This corresponds to an infinite inductance or an open switch in the equivalent switching circuit. Suppose also that a voltage e is applied across N turns in such a direction as to increase the flux in the core. After a certain time t, the flux will have changed $\Delta\phi$ as given in equation 3, and now sits at point B. Here the switch is either open *or* closed. If current should flow, the flux would be driven out to point C, closing the switch. If the flux is between A and B the switch is open; between B and C it is closed.

▲ Fig. 7. Input stages of pulse generator redrawn for clarity.

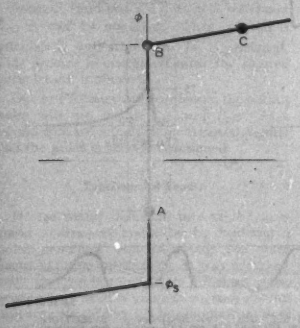


Fig. 6. Idealized ϕ–I characteristic of typical core.

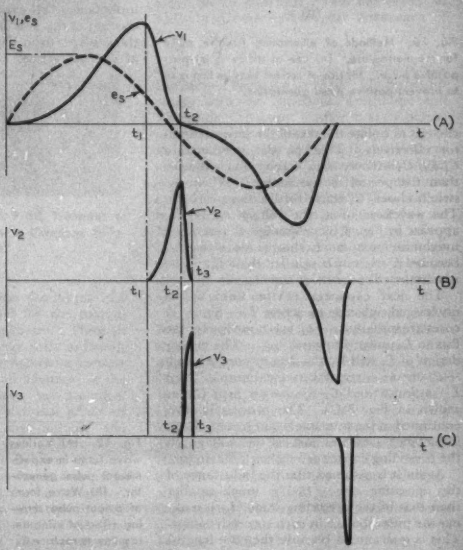


Fig. 8. Voltage wave forms for input stages of pulse generator. ▶

Operation

The operation of the pulse generator may now be readily understood. The following initial conditions are assumed and will be justified by showing that these conditions are again present at the end of one complete cycle. The assumptions are (1) all cores are initially at $-\phi_s$ and unsaturated, and (2) all capacitors are uncharged.

As a further condition, all the capacitors, $C_1, C_2, \ldots C_n$, are made equal in value. This is not a restriction, since each capacitor must store the same energy at the same voltage.

Consider the input section of the pulse line redrawn in Fig. 7. The flux in core 1 is at $-\phi_s$ and the core is unsaturated. The switch is open, leaving L_{s1} and C_1 out of the circuit. When $e_s(t)$ is switched on, an a-c transient starts in L_0 and C_1, producing a voltage v_1 across C_1, as shown in Fig. 8(A). The voltage v_1 builds up to a maximum value in time t_1. (Time t_1 does not occur at a zero of $e_s(t)$ as the resonant frequency of L_0 and C_1 is not necessarily equal to ω_s.) Eventually, v_1 would reach some steady-state a-c value if L_1 and C_1 actually were not present.

Recall, however, that C_1 is uncharged and hence v_1 also appears across L_1. The flux in the core of L_1 has increased from $-\phi_s$ by absorbing volt–time integral, $1/N_1\int_0^t v_1 dt$.

The core of L_1 will reach $+\phi_s$ when $t = t_1$, if it is properly designed. This can be done by proper selection of material B_s, core area A_1, and number of turns N_1.

The circuit composed of C_1, L_{s1}, and C_3 must be considered when L_1 saturates at time t_1. C_3 is initially uncharged, C_1 is charged to the maximum value of v_1, and it is assumed that L_{s1} is much smaller than L_ϕ. The effect, then, of the source on the circuit can be neglected, inasmuch as L_ϕ is large enough to isolate the rest of the pulse generator effectively. That is, the transient in C_1 L_{s1} C_3 will occur in a time much shorter than the period of the source. When the switch closes, C_1 starts to discharge into C_3. The waveform of v_3, the voltage across C_3, appears in Fig. 8(B). Voltage v_3 reaches a maximum in a much shorter time than t_1 because L_{s1} is much smaller than L_ϕ. The maximum of v_3 occurs at time t_2.

The next capacitor in the line (C_4) is uncharged, placing v_3 across L_3. Since *all* cores are initially at $-\phi_r$, v_3 is now driving the flux in L_3 upward toward $+\phi_s$. The proper design of L_3 will let the flux in core *2* reach $+\phi_s$ just as v_3 reaches its maximum. Then L_3 saturates and C_3 discharges into C_4, as shown in Fig. 8(C). The process is then continued in the next stage, and so on. Each inductance saturates just as the voltage on the preceding capacitor reaches a maximum.

Again it is assumed that the inductance of the operating stage (L_{s3}) is much smaller than that of the preceding stage (L_{s2}), making the pulse shorter in each successive stage. This is guaranteed because the core lengths are yet unspecified and may be adjusted to achieve $L_{sk-1} << L_{sk}$.

In the nth stage, the pulse is delivered to the load, as shown in Fig. 9(A). L_n saturates just as C_n is fully charged, and allows C_n to discharge into the load. L_{sn} will always be small enough to make this last discharge a fully damped RLC discharge, as shown in Fig. 9(B).

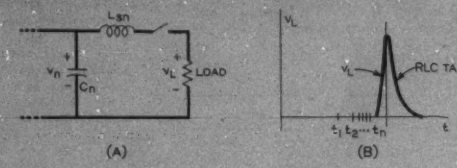


Fig. 9. Output stage. (A) Circuit. (B) Voltage wave form.

The assumed initial conditions must now be justified. All capacitors are discharged, as the initial charge on C_1 has been transferred down the line without loss (assuming no resistance in the inductances) and ultimately dissipated in the load. The cores now all sit at $+\phi_s$ and are unsaturated, inasmuch as no currents are flowing in the inductances (all capacitors uncharged). At the end of the next half cycle (also shown in the wave forms in Fig. 8) all the cores will be at $-\phi_s$ as assumed.

Essentially, then, the operation consists of a cascaded discharge with the period of each voltage pulse decreasing.

Practical Considerations

Perhaps the most serious departure of the practical device from the idealized pulse generator presented here is that the inductances have finite resistances. Because the energy must be transferred from capacitor to capacitor very rapidly in the final stages, very high currents are encountered. The windings of the final inductances must, therefore, consist of only a few turns of very large wire to keep the voltage drops down in these stages.

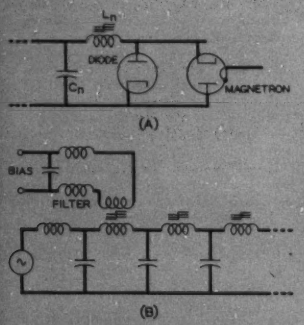


Fig. 10. Methods of eliminating positive pulse for magnetron use. (A) Use of diode to by-pass positive pulse. (B) Use of current bias on first core to prevent positive pulse generation.

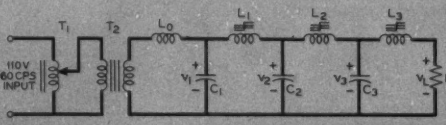


Fig. 11. Experimental model pulse generator.

In radar applications, where the quality of the microwave spectrum emitted by the magnetron depends largely on the squareness of the input voltage pulse, it is desirable to replace the final capacitor, C_n, with a pulse line having a capacitance equivalent to it.

The pulse generator shown here could be used to drive a magnetron directly. Some means of eliminating the positive pulses would be necessary, however, such as the reverse diode shown in Fig. 10(A). This, of course, would cut the over-all efficiency in half.

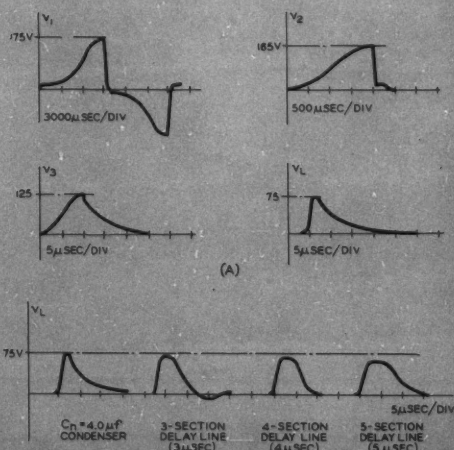


Fig. 12. (A) Various wave forms in experimental pulse generator. (B) Wave forms of output pulse showing effect of using delay line to replace C_n.

A more desirable solution is shown in Fig. 10(B). If a small bias current is applied to the first core, it will keep the core from saturating in one direction. Thus, pulses of only one sign are produced in the first stage and passed along. This also makes the pulse repetition rate exactly equal to the source frequency instead of twice the source frequency.

Occasionally, when every high pulse repetition rates are desired, it is not feasible to use an a-c source. In this case, a switched d-c source, using a hard switching tube or thyratron, may be substituted, giving repetition rates of 2,000 cycles per second or higher. The analysis of the circuit for switched d-c input is exactly the same after the input stage. The analysis of the input stage is similar, requiring change only in the shape of the transient voltage v_1.

Design

The design of a practical pulse generator of this type is not straightforward. A trial-and-error solution is required, with the first trial being the idealized case presented here.

For radar use as a magnetron modulator, the "load" will usually be specified as a peak pulse power P_{pk}, a peak voltage V_{pk}, a pulse length t, and a repetition rate f. The source frequency is determined by f. The source voltage is then transformed to approximately V_{pk}. C_1 is then chosen to store energy $P_{pk} \times t$ at voltage V_{pk}. L_0 is chosen to give resonance of L_0 C_1 at approximately $1.8f$ (a more elaborate analysis gives this figure[5]).

Then v_1 is computed and $\int_0^{t_1} v_1 dt$ is computed, where v_1 maximum occurs at t_1. This specified the turns–area product for a given material ($N_1 A_1 B_s$). The core length is chosen to accommodate the required number of turns. This specifies the value of L_1. Then L_{g1} may be measured. (Calculation of the saturated inductance is extremely difficult for fully wound toroidal cores.)

From C_1 (and hence C_2, since $C_1 = C_2$) and L_{g1}, v_2 can be obtained. Then $\int_{t_1}^{t_2} v_2 dt$ is calculated, and from this L_2 is designed. This process is continued until the desired pulse length is obtained.

Due to I^2R losses and core losses, the output pulse will not be at V_{pk} and P_{pk}. As a second trial the input voltage is raised slightly and the pulse generator redesigned.

Experimental Results

It was found desirable to test the foregoing analysis of operation by building a pulse generator and observing the wave forms actually occurring. It was economically impossible to build a full-sized pulse generator to drive a magnetron, so a smaller unit was considered. The components used were limited to those readily available. The resulting pulse generator is schematically shown in Fig. 11.

The wave forms are shown in Fig. 12 as nearly as they could be copied from photographs. The output pulse length was about 3 microseconds to the half power points and about 10 microseconds to the 10 per cent power points. The peak pulse power obtained was approximately 5.6 kilowatts. The input power measured 8.0 watts at 0.8 power factor and the output power was estimated to be between 4.0 and 6.0 watts by graphic integration of the wave form and heating of the load resistor. This gives an over-all efficiency of 50 to 75 per cent.

The various practical considerations mentioned previously were tried on this model circuit. A small 4-section lumped delay line was constructed and substituted for C_2 with noticeable improvement in the output wave form. A bias winding of about 50 turns was added to L_1 and a low-voltage, high-current source was connected. By varying the bias it was possible to vary the phase between the positive and negative pulses or eliminate either without noticeable effect on the quality of the output pulse of the generator.

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An Electrical Engineer in Communications

WALTER J. BARRETT, M '36, F '50, Treasurer of AIEE, New Jersey Bell Telephone Company transmission maintenance engineer.

"Every electrical engineer should join the AIEE. It is the medium for the mutual education of electrical engineers. Through its publications and meetings, since its founding in 1884, it provides the means for keeping members up to date on all advances of the art. Active participation in technical groups, the section, and national affairs of AIEE have broadened my outlook, and enlarged my circle of friends and contacts. My experience conclusively has demonstrated that AIEE membership is a valuable asset to me as a practicing electrical engineer. The Institute has shown me that it is a leader in advancing the technical and educational progress of the engineering profession as a whole through such co-operative projects as the United Engineering Trustees, Inc. (UET), the Engineering Foundation, the Engineering Societies Library, Engineers Joint Council (EJC), and Engineers Council for Professional Development, in all of which AIEE has taken an active and constructive part since each of them was organized."

W. J. Barrett received the degree of electrical engineer *cum laude* from The Polytechnic Institute of Brooklyn in 1920. He began his career with the American Telephone and Telegraph Company. After a brief period in one department, he was assigned to transmission engineering and then to electrical coordination of power and communication systems, the field which he has found most interesting and in which most of his work has been done. In 1930, he was assigned to the New Jersey Bell Telephone Company, where he is now transmission maintenance engineer, and where he also supervises relations with the electric utilities in both structural and inductive co-ordination.

Mr. Barrett's AIEE service started in the New York Section's Communication Division, of which he became chairman. He was founder of the New Jersey Division, and chairman of the New York Section in 1947–48. In 1948, he was secretary of District 3, and the following year was elected to the Board of Directors. He resigned as a director in 1953 to become Treasurer of the Institute, which office he still holds. He has an active interest in all intersociety relations, and represents AIEE on the Boards of Directors of EJC and UET, and has been president of the latter organization since February 1955.

Electrical Engineering Education

ASEE To Make Study of Technical Institute Education

A $38,000 grant from the Carnegie Corporation of New York to the American Society for Engineering Education (ASEE) will make possible a comprehensive study of technical institute education in the United States.

Plans for the study were announced by E. E. Booher, executive vice-president of the McGraw-Hill Book Company, at the general session opening the 64th annual meeting of the ASEE in Ames, Iowa. Prof. G. R. Henninger, assistant director of the Engineering Extension Service at Iowa State College, will be director of the project.

The project, said Mr. Booher, will have a threefold purpose:

(1) To identify the industrial, technological, and educational trends which influence the education and careers of graduates of two-year technical institutes.

(2) To assess the place of the technical institute in higher education, and to determine the present capacity and status of technical institutes in the United States.

(3) To project the future role of the technical institute in meeting the nation's needs for scientific and engineering manpower.

Prof. K. L. Holderman, assistant dean of the College of Engineering and Architecture at the Pennsylvania State University, is chairman of the project committee. Its members include H. R. Beatty, president of Wentworth Institute, Boston, Mass.; Dr. M. M. Boring, president of the society and consultant on engineering manpower at the General Electric Company; Dean C. J. Freund of the College of Engineering, University of Detroit; Prof. G. A. Gullette, head of the department of social studies at the North Carolina State College; Prof. R. L. Shurter, director of the Humanistic-Social Division at the Case Institute of Technology, Cleveland, Ohio; and Dean L. F. Smith of the Rochester Institute of Technology.

The study will be organized during the current meeting of the society, and the field survey will begin in the Fall. A preliminary report is scheduled for the 1957 annual meeting of the society, and a final report will be made during 1958.

Fellowships and Scholarships Awarded to 53 Students by RCA

This Fall, 53 students at colleges and universities across the nation will receive Radio Corporation of America (RCA) Fellowships and Scholarships for the 1956–57 academic year, Dr. C. B. Jolliffe, vice-president and technical director, RCA, announced recently.

Under the RCA aid-to-education program now entering its 12th consecutive year, RCA will award 20 fellowships and 33 scholarships, it was stated by the chairman of the RCA Education Committee. The total amount allocated for these grants is $117,900.

A new provision of the program is an annual contribution of $500 for each nontax-supported institution where a scholarship is maintained. An unrestricted gift of $750 also is made to each university where RCA Fellowships have been established.

More than 30 colleges and universities in 20 states and the District of Columbia will share in the fellowship and scholarship grants for their students. The RCA awards are currently offered at all classes of universities—large and small, state and privately endowed. They encompass the fields of science, industrial relations, dramatic arts and music. For the first time, an RCA Fellowship in medical electronics will be awarded at Johns Hopkins University.

Dr. Jolliffe said RCA Fellowships and Scholarships are administered directly by the colleges and universities where they have been established. The institutions set up the requirements for the awards and select the recipients.

The 20 RCA Fellowships, to be awarded during the next college year, have been assigned as follows:

Ten fellowships for graduate students studying in designated departments at: California Institute of Technology, New York University, Princeton University, Rutgers University, University of Illinois, Columbia University, Cornell University, Yale University, Carnegie Institute of Technology, and Johns Hopkins University.

Ten David Sarnoff Fellowships, established this year in honor of the Chairman of the Board of RCA, will be presented to RCA employees who have been selected to study for advanced degrees. Six fellowships are awarded in the field of science, three in business administration, and one in dramatic arts.

The annual grant for all RCA Fellowships provides full tuition costs, $2,100 to the student to help defer living expenses, and $750 as an undesignated gift to the university attended by the RCA Fellow. The total value of a fellowship varies, but on the average is approximately $3,500.

The 33 RCA Scholarships, each providing grants of $800, to be awarded this Fall will be apportioned as follows:

Scholarships numbering 29 for undergraduate students in the field of science, unless otherwise indicated, at: California Institute of Technology, Carnegie Institute of Technology (dramatic arts), University of Cincinnati, Columbia University, University of Florida, Franklin and Marshall College, Harvard University, Howard University, Indiana University, Iowa State College (science and dramatic arts), University of Kansas, University of Michigan (industrial relations), University of Minnesota, North Carolina State College, University of Notre Dame, Oberlin College (music), Princeton University, Purdue University, Rutgers University, University of Santa Clara, Swarthmore College, Union College, University of Washington, Wellesley College, West Virginia University, University of Wisconsin, and Yale University (science and dramatic arts).

Four additional scholarships in science or engineering will be given to honor students of RCA Institutes for study at colleges selected by the recipients.

Program for Training Nuclear Reactor Engineers Offered by AEC

The Atomic Energy Commission (AEC) recently announced that it has invited proposals from colleges and universities to establish and conduct courses in nuclear reactor technology and supporting subjects as part of a program to double the number of nuclear reactor engineers trained each year at the Oak Ridge School of Reactor Technology (ORSORT) at the Oak Ridge National Laboratory (ORNL), Oak Ridge, Tenn.

The program provides that students accepted for the ORSORT will take the first six months of their training at colleges or universities beginning about March 1, 1957, and the remaining six months at ORNL. At the present time, the entire one-year course is given at Oak Ridge.

The universities and colleges were invited to submit proposals before September 15, 1956, under which they would provide preparatory work for the students by giving concentrated preparatory instruction in mathematics, physics, chemistry, and engineering. The subjects to be covered in the university phase of the proposed program will be unclassified. The ORSORT portion of the program will cover classified subjects and will be concentrated in order to take advantage of the unique facilities and the latest technology available at ORNL.

The proposals invited by the AEC are to cover classes of six-months duration beginning in March 1957. The AEC will enter into contracts for the courses with colleges and universities submitting acceptable proposals.

The number of students enrolled in the ORSORT course which began in September 1956, has been increased from 90 to 120 in response to the growing demand for trained nuclear reactor engineers. Because of the limited facilities available at Oak Ridge the school cannot accommodate more than 120 in each class. The proposed program would permit two groups of 120 students each to be accepted for the course each year.

ORSORT is a graduate level school providing both the engineer and the scientist with advanced training applicable to the design, construction, and operation of nuclear reactor systems. The first school of its kind, ORSORT was established in 1950 by the

ORNL, which is operated by the Union Carbide Nuclear Company, to fill the need for trained personnel in the AEC reactor development programs. More than 450 students have been graduated to date.

Applicants for admission to ORSORT may be sponsored by AEC, its contractors, other Government agencies and their contractors, and industrial organizations having an active interest in development of reactors or reactor components. Under the proposed program, students would be selected by a committee on admissions composed of university, AEC, and ORNL representatives.

Inquiries regarding proposals should be directed to: Dr. H. M. Roth, director, Research and Development Division, U. S. Atomic Energy Commission, P. O. Box E, Oak Ridge, Tenn.

Five-Year Program Planned by University of Maryland and Navy

A five-year work-study program for Washington, D. C., metropolitan high school graduates, designed to relieve a critical shortage of engineers at the Bureau of Ships, has been arranged between the University of Maryland and the Department of the Navy.

In announcing the new co-operative arrangement, Dean S. S. Steinberg of the University's College of Engineering stated that the new program will consist of planned work assignments in the Bureau combined with the completion of academic study leading to a bachelor of science degree from the University in mechanical, electrical, or civil (naval architecture) engineering.

Selection of high school students for participation in the new project will be made on the basis of a competitive examination including such factors as successful completion of the Civil Service Commission Engineering Aid examination, scholastic record, other test scores, and reference checks.

Additionally, those selected by the Bureau must also meet the entrance requirements of the University's College of Engineering.

Initially employed as GS-2 Engineering Aids, selected students will spend five fall semesters and three spring semesters at the University of Maryland, completing a full four-year engineering degree program; and, two spring periods and five summer periods at the Bureau of Ships.

While at the Bureau, the participant will work on a series of planned rotational assignments which will give him progressively more technical responsibility.

The promotional pattern of the student will lead to a GS-5 Engineer rate upon completion of the training agreement.

Participants enrolled in the program will also enter into an agreement obligating them to continue work with the Bureau for a five-year period upon completion of their training.

Tuition costs, expenses for text books, laboratory fees, and instructional material for all courses prescribed for degree requirements will be defrayed by the Bureau.

Work Begun on New Scientific and Engineering Education Center

The Polytechnic Institute of Brooklyn has begun the conversion of the huge industrial plant, which it purchased in 1954 for $2 million from the American Safety Razor Corporation, into a modern center of scientific and engineering education with the signing of a contract with the W. J. Barney Corporation, 101 Park Avenue, New York, N. Y.

Dr. H. S. Rogers, president of the Institute, has announced that the Barney Corporation will co-ordinate and supervise the conversion where 6,000 students are to be accommodated and which is expected to cost between $1.5 and $2 million. It also will advise on all subcontracting. A. L. Craft, 133 East 39 Street, New York, N. Y., is the architect.

Scholarship Winners Tour Ohio Brass Factory

The two 1956 winners of Ohio Brass (OB) Foundation scholarships recently visited the Ohio Brass Factory in Barberton. Quality control foreman Eugene Linder pointed out many of the plant's operations and processes to G. W. Nelson of Mansfield, Ohio, and R. T. Cunningham of Barberton.

The OB Foundation, a nonprofit organization established by the Ohio Brass Company, awards scholarships to students from its plant areas who plan to seek degrees in certain of the technical sciences. Awards are based on scholastic standing, leadership qualities, personality, and other factors.

Mr. Nelson plans to major in chemical engineering, at Case Institute of Technology; Mr. Cunningham will study mechanical engineering, at Purdue University.

The OB Foundation scholarship provides for payment of all tuition and academic fees and part of the room and board expense for each winner during an entire four- or five-year course of study.

AEC Approves Uranium Loan to Alabama Polytechnic Institute

The Atomic Energy Commission (AEC) has announced approval of a loan of 5,500 pounds of natural uranium metal, plus a neutron source, to the Alabama Polytechnic Institute, Auburn, Ala. The uranium will be used in a subcritical assembly for the training of nuclear engineers.

The subcritical assembly consists of an arrangement of uranium rods in a moderator such as graphite or ordinary water. When the neutron source is introduced, nuclear fission is produced, but the reaction cannot be sustained without the presence of the neutron source.

The facility requires no unusual safety controls, expensive shielding or heat removal equipment and may be used for many laboratory exercises in nuclear engineering training.

This brings to six the number of loans of this type to nonprofit educational institutions. Previous recipients are New York University, University of Florida, Virginia Polytechnic Institute, Massachusetts Institute of Technology, and the City College of New York.

For some time, the AEC has been supplying certain materials for these assemblies without a use-charge being made, subject to the availability of the material and to a determination that such loans will result in a net advantage to the AEC program to assist in alleviating the current shortage of nuclear scientists and engineers.

WINNERS of Ohio Brass Foundation 1956 scholarships, G. W. Nelson (center) and R. T. Cunningham (right), were guided on a tour through the Ohio Brass Factory by Eugene Linder (left), quality control foreman.

Courtesy Ohio Brass Company

MODEL of a sun-powered aircraft carrier using converted energy is launched by H. L. Hoffman, president, Hoffman Electronics Corporation.

down. A major radio manufacturer has placed one of these solar cell operated portables on the market recently.

The once science-fiction idea of having solar-cell shingles on the roof of a house to supply light and power for an entire family no longer can be considered as purely visionary, in view of recent developments.

50-Kw Reactor for Industrial Research and Development

Private industrial research began recently with the first 50-kw nuclear reactor built intended solely for peacetime use by industry.

Located on the campus of the Illinois Institute of Technology, Chicago, Ill., the Armour Research Foundation (ARF) reactor opens an entirely new field in industrial research and development by providing an on-the-spot source of high-energy gamma rays and neutrons. Short-lived radioisotopes, useful in medical, industrial, and scientific research, will be available locally from the reactor. It will not be used to generate any electric power.

The "solution type" reactor uses as "fuel" enriched uranium dissolved in about 4 gallons of water. Atomic fission, the "splitting" of atoms which produces radioactivity and neutrons, takes place in the reactor core, a steel sphere about one foot in diameter, which is surrounded by an 8 × 5 × 5 foot stack of graphite bars which act as a reflector. Dense concrete, five feet thick, forms the exterior shield.

Rate of fission in the reactor is controlled by four boron rods. When placed near the reactor core the rods absorb neutrons, thus stopping the fission process. When the rods are withdrawn fission begins again.

A particular feature of the reactor is its "self contained" design which confines all the radioactivity within the shield. No gaseous or liquid materials are exhausted or discharged.

The reactor will be used in many fields including biology, petroleum technology, metallurgy, electronics, textiles, and chemistry. Of particular interest are studies in the atomic radiation of foods to extend the length of time they can be kept edible. Among the processes offering promise are the pasteurization of fresh meat to extend its shelf life, "cold" sterilization of meats and vegetables for indefinite storage, deinfestation of grains and flour, and prevention of sprouting in potatoes and onions.

Radioisotopes provide some of the most useful and promising application of the reactor. Such "short-lived" isotopes have not been widely used because of the time delay and resultant radioactivity loss if moved over long distances.

In addition to the reactor for the ARF, Atomics International, Division of North American Aviation, Inc., Los Angeles, Calif., has contracted to build a research reactor for the Atomic Energy Research Institute of Japan and a medical reactor for the University of California at Los Angeles Medical Center.

The installation will enable industry for the first time to conduct reactor studies without security restrictions and military competition.

The Armour reactor is the first since the original nuclear reactor at Stagg Field, Chicago, to be constructed in a highly populated area.

As an instrument of research, the reactor makes possible:

(1) Study of the influence of radiation on chemical reactions, plastics, glasses, organic systems, and certain alloys.

(2) Chemical analysis through neutron activation—the most sensitive method known for measuring impurities in rare quantities.

(3) Structure analysis potentially more powerful than the standard X-ray diffraction techniques.

The reactor is a "water boiler" type capable of operating at a power level of 50 kw, employing fuel in the form of a water solution of uranyl sulphate—approximately one kilogram of U-235. The fuel has been obtained from the Atomic Energy Commission (AEC) on "extended loan," as required by federal law.

The ARF reactor is a homogeneous solution-type reactor, designed to operate at 50 kw and to produce a maximum thermal neutron flux of about 1.7×10^{13} neutrons/cm^2-sec at the center of the reactor core. The reactor consists of a core assembly, gas-handling, fuel-handling, and cooling systems, a control- and safety-rod system, and a reflector assembly, together with the necessary instrumentation and shielding for safe and efficient operation. In addition, exposure facilities are provided through which the neutron flux and gamma-ray radiation are available in various intensities for experimental purposes.

Shielding for the reactor is provided by a five-foot thick biological shield of dense hematite-colmanite concrete which surrounds the reflector and the subpile room. In addition, lead shields and bismuth windows are provided for special shielding purposes, as required. The concrete shielding is suffiicent to reduce radiation levels at the outer surface to less than one tenth of the generally accepted safe dosage rate specified for laboratories handling radioactivity.

The instrumentation system consists principally of circuits which monitor reactor power and the performance of the gas-handling and cooling system. In addition, there are instruments associated with other important variables, and there is provision for area radiation monitoring and similar instrumentation.

Power level is measured by fission chambers and gamma-compensated ion chambers. Temperature-, pressure-, and flow-measuring instruments for gas-handling and cooling system monitoring include instruments measuring sweep-gas flow, core temperature, catalyst-bed temperature, recombiner gas pressure, hydrogen concentration, sweep-gas temperature, and surge-tank level.

The reactor is shut down automatically in the event the flux level or change in flux level exceeds present values, if a malfunction occurs in the auxiliary equipment, or in the event of a power failure. The shutdown is accomplished by circuits which de-energize the magnets which hold the control and safety rods, causing them to fall by gravity into the core. When shutdown occurs, instruments on the control console indicate to the operator the nature and location of the malfunction.

To take advantage of the gamma activity produced by the fission-product gases circulating through the gas recombiner tank, exposure facilities are provided which extend from the subpile room into the exposure room and into the valve room.

As an example of the new and powerful techniques made possible by the reactor, "neutron activation" now permits what is probably the most sensitive method of chemical analysis known to date. For many elements, a sensitivity of detection of one-trillionth of a gram can be achieved.

Another newly developed technique is that of "neutron diffraction." Since the diffraction of neutrons is almost independent of atomic number, there is now available a powerful method of structure analysis which complements, and frequently exceeds, the standard X-ray diffraction techniques. This technique has already proved valuable in the study of organic compounds, hydrogen and oxygen in solids, and antiferromagnetic materials.

Bombardment of materials by radiation produces effects in almost infinite variety—usually deleterious, but occasionally beneficial. The study of such effects in glasses, plastics, organic systems, and metallic alloys

can be undertaken readily with the reactor. The flux also will permit study of the influence of radiation on chemical reactions, some of which are known to accelerate under these conditions.

Twenty-four industrial companies are participating in the nuclear reactor research program at Armour Research Foundation; and under the participator plan, each firm is contributing $20,000 toward the construction and initial operation of the $700,000 reactor facility with ARF providing the remaining funds.

In return, the companies involved will share in the benefits of an extensive three-year program the aim of which is the application of atomic techniques to industrial problems.

Other features of the participator plan include detailed technical advice, certain patent benefits, and limited specialized training.

PHYSICIST checks core for 50-kw nuclear research reactor, the first for private industrial research.

Weapons Test Devices Aid Services in Various Ways

The first successfuld emonstration of closed-circuit color television utilized to observe firing of ballistic missiles was recently held at the U.S. Army facilities of the Missile Test Center at Cape Canaveral, Fla. For security reasons, specific details of the demonstration were not disclosed. However, use of closed-circuit color television afforded Army observers a close-up view for the first time of actual variations in flash and flame at the launching of a Redstone Missile.

The first few seconds of missile launching are very critical and prior to the color television demonstration, detailed and close-up visual observation was "next to impossible" because of required safety precautions and extreme variations of brightness as the missile was fired.

During the demonstration, color television cameras were mounted atop a concrete blockhouse about 300-feet from the launching platform. They were focused on the Redstone's tail section. Monitors, or receivers, were viewed within the safety of the blockhouse.

The missile launching suddenly lighted the predawn darkness with a brilliant flash, brighter than the noon-day sun. Despite the extremes in light variation, however, color reception was excellent, with great stability, true color, and no noticeable sonic vibration.

Remote-controlled cameras used during the demonstration were standard, field-sequential closed-circuit color equipment developed by General Electric Company (GE) television engineers at Electronics Park, Syracuse, N. Y.

The series of demonstrations included tests under conditions of both near-darkness and extreme brightness. Observers viewed the firings on monitors similar to, but of higher quality than, home-type television receivers.

Although the firing was viewed from a distance of but 300-feet and on home-sized screens it is said to be feasible to view such events from thousands of miles away and on large, theater-size screens. The demonstrations prove the effectiveness of television's watchful eye to see where you cannot be, or do not want to be.

Prior to the GE color demonstrations, Army observers had to view missile firing through narrow tinted-glass ports, or at extreme distances with the aid of telescopes, movie cameras, or complicated transits. Tinted glass, however, distorted true colors of the flash, while use of the other devices was limited by weather and atmospheric conditions.

Monochrome, or black-and-white, television has long been used for observing at safe distances the firing of some types of rocket motors in static test stand. However, this was the first time closed-circuit color television was successfully demonstrated.

Another of these special devices is a recording installation at the world's longest missile test range. The Air Research and Development Command (ARDC) has contracted the Consolidated Electrodynamics Corporation, Pasadena, Calif., for $1 million, to provide complete magnetic-tape instrumentation along the 5,000 mile test range.

ARDC's test range stretches southeastwardly from the launch site outside the Missile Test Center, Patrick AFB, Fla., across the Atlantic Ocean to Ascension Island off the coast of Africa. It is here the Air Force plans to test intercontinental ballistic missiles.

The magnetic-tape equipment, placed at over 100 strategic points on the ground and aboard ships along the 5,000 mile range, will record telemetered data from the missiles, such as temperature, pressure, and thrust, and play it back for analysis and interpretation.

The U.S. Navy also has developed a television camera for close-up viewing of its weapons during tests.

With this new television camera taking over the role of observer, top ranking military officers recently got their first close-up look at high powered weapons being tested.

The camera, which will contribute to efficiency and safety in weapons testing, was demonstrated at the Chincoteague (Va.) Naval Air Station by the Navy and General Precision Laboratory, Pleasantville, N. Y.

Representatives of the U.S. Navy, U.S. Air Force, and U.S. Marine Corps were able to observe performance of the advanced

Future Meetings of Other Societies

Pennsylvania Electric Association, Fall Meeting:
- *System Planning Committee,* October 1–2, Skytop Lodge, Skytop, Pa.
- *Electrical Equipment Committee,* October 4–5, Arlington Hotel, Binghamton, N. Y.
- *Systems Operation Committee,* October 10–11, Penn Alto Hotel, Altoona, Pa.
- *Motor Committee,* October 18–19, Split Rock Lodge, White Haven, Pa.
- *Communications Committee,* October 22–23, Fort Stanwix Hotel, Johnstown, Pa.

Canadian-IRE, Convention and Exposition, October 1–3, Automotive Building, Exhibition Park, Toronto, Ont., Canada

The Electrochemical Society, Semiannual Meeting, October 1–4, Statler Hotel, Cleveland, Ohio.

American Mining Congress, Metal Mining Industrial Minerals Convention and Exposition, October 1–4, Shrine Exposition Hall, Los Angeles, Calif.

Porcelain Enamel Meeting, ASTM Committee C-22, October 2–3, Battelle Memorial Institute, Columbus, Ohio.

Standards Engineers Society, 5th Annual Meeting, October 3–5, Willard Hotel, Washington, D. C.

International Association of Electrical Leagues, 1956 Conference, October 3–6, Sheraton-Cadillac Hotel, Detroit, Mich.

SMPTE, 80th Convention, Exhibits, October 8–12, Ambassador Hotel, Los Angeles, Calif.

International Science and Human Welfare Conference, American Institute of Geonomy and Natural Resources, Inc., October 8, Washington, D. C.

Civil and Military Aeronautical Communications, 2nd Annual Symposium, Rome Air Development Center Griffiss A.F.B., October 8–9, Utica, N. Y.

EJC, Engineering Societies of Western Hemisphere, 4th Convention, October 8–12, Mexico City, D. F., Mexico.

Computer Applications Symposium, 3rd Annual Meeting, October 9–10, Morrison Hotel, Chicago, Ill.

International Scientific Radio Union, Fall Meeting, October 11–12, University of California, Berkeley, Calif.

NNAS, 7th Annual Symposium, October 11–12, Armour Research Foundation, Illinois Institute of Technology, Chicago, Ill.

Radio Fall Meeting, RETMA, October 15–17, Hotel Syracuse, Syracuse, N. Y.

NACE, Technical Fall Division Meetings:
- *Northeast Region,* October 15–17, Drake Hotel, Philadelphia, Pa.
- *South Central Region,* October 23–26, Gunter Hotel, San Antonio, Texas
- *North Central Region,* November 15–16, Hotel Statler, Detroit, Mich.

ASCE, Annual Meeting, October 15–19, Jackson, Miss.

National Conference on Industrial Hydraulics, 12th Annual Meeting, October 18–19, Illinois Institute of Technology, Chicago, Ill.

Institute of Management Sciences, 3rd Annual Meeting, October 18–19, Hotel Statler, Los Angeles, Calif.

Society of American Military Engineers, October 19–20, Atlanta, Ga.

RTCA, Annual Fall Meeting, October 22–23, CAA Tech. Dev. Center, Indianapolis, Ind.

National Safety Council, 44th Congress and Exposition, October 22–26, Chicago, Ill.

Air-Conditioning and Refrigeration Institute:
- *Board of Directors,* October 22–23, Grand Hotel, Point Clear, Ala.
- *Product Sections,* October 24–26, New Orleans, La.

ASA, 38th Annual Meeting and 7th National Conference on Standards, October 22–24, Hotel Roosevelt, New York, N. Y.

SPE, Isocyanate Symposium, October 23, Curtis Hotel, Minneapolis, Minn.

Prevention of Equipment Deterioration Symposium, October 23–25, U. S. Naval Civil Engineering Research and Evaluation Laboratory, Port Hueneme, Calif.

Aircraft Electrical Society, Annual Electric Equipment Display, October 25–26, Pan-Pacific Auditorium, Los Angeles, Calif.

Aeronautical and Navigational Electronics East Coast Conference, 3rd Annual Meeting, October 29–30, Fifth Regiment Armory Exhibit Hall, Baltimore, Md.

Official photograph, U. S. Navy

Official photograph, U. S. Navy

OFFICER GROUP *(right)* **receives briefing prior to getting close-up look at weapons tests at Naval Aviation Ordnance Test Station. Rugged television camera (above), mounted on stand inside test chamber, observes weapons firing from distance of three feet and relays to room 150 feet away where pictures are projected on a movie-size screen.**

weapons from a distance of three feet—the distance the television camera was located from the weapons—while looking at a movie-size screen 150 feet from the firing bay.

The unusual display by the Aircraft Weapons Department of the Naval Aviation Ordnance Test Station was made possible through the use of an especially rugged television camera mounted on a tripod close to the firing weapon inside the test chamber, and another small five-pound camera peering through the glass observation port in the two-foot-thick concrete wall at the rear of the chamber.

Pictures from either camera controlled by a switching device were relayed to a television projection system in the viewing room where the large group of officials was able to watch the proceedings easily and safely.

The closed-circuit television equipment transmitted clear, detailed pictures of the tests despite noise levels over 120 db and shock waves produced by the firing weapon.

The equipment also provided close-up views of the weapons which previously were impossible to obtain because of necessary safety factors.

Mechanized Process Mass Produces UHF Transistors

A new technique for mass production of high-speed and ultrahigh-frequency transistors, recently announced by Philco Corporation, represents a major advance in semiconductor technology. Two types of transistors, a Micro-Alloy Transistor (MAT) and a Surface-Barrier Diffused Transistor (SBDT), the direct result of this new technique, are now in engineering development.

Developed at Philco's Research Laboratories in co-operation with the U. S. Navy, U. S. Army Signal Corps and the U. S. Air Force, the new devices will be produced by the Lansdale Tube Company, Division of Philco, at its new semiconductor plant at Spring City, Pa. The MAT and SBDT may be used in electronic "brains," guided missile communications, radar, other military equipments.

The MAT and SBDT devices are fabricated from the element germanium and are utilizing a unique surface-barrier technique. This process, now highly mechanized, permits mass production of transistors requiring precision control of critical dimensions. It avoids necessity of manually assembling the germanium and the electrode material and alloying them in a furnace.

Primarily designed for high-speed electronic computers, the MAT employs a new Philco "microalloying process" which uses doped semiconductor layers only a few millionths of an inch thick. In conventional alloying, the doped layer must be made relatively thick, and due to the basic nature of the alloying process, is difficult to control. The new device is reported to be at least 10 times faster than the fastest vacuum tube in electronic computers.

SBDT (surface-barrier diffused transistor) in precision plate position. Operator is illustrated inserting carrier into precision plating position.

The other new device, the SBDT, will operate in the ultrahigh-frequency range of 500 megacycles. It will find its widest use in the 20- to 200-mc range. This transistor, which also utilizes Philco's electrochemical and microalloying techniques, permits the effective use of what is known as "surface diffusion." In this particular process, the tiny germanium transistor blanks are subjected to a very carefully controlled "atmosphere" at high temperatures. This atmosphere contains particles of metal in gaseous form. When properly controlled, atoms of the metal penetrate the surface of the germanium by diffusion. The SBDT technique, using highly mechanized precision etching, results in transistors having α cut-off frequencies above 600 mc.

The new MAT and SBDT semiconductors will join a group of Philco transistors that runs the gamut from milliwatt hearing aid amplifiers to 10 watt power units, in addition to 40- to 80-mc surface barrier transistors used in computers, communications, and military equipments.

Special Studies, Grants, Research Programs, and Seminars

Oceanographic Research. A 65-foot schooner will be used by New York University (NYU) to study a variety of scientific problems—from the effect on radar of tiny ocean waves to long-range weather forecasting.

The vessel will be put to use first by the NYU engineering research division in a study of air-sea boundary processes. In this project, scientists are measuring the energy and frequency of tiny ocean waves (less than two inches high) to find out exactly how they reflect radar signals and reduce radar's usefulness in navigation.

Study of Radio Wave Absorption. Prof. Willis M. Rayton, Dartmouth College physicist, has received a grant of $15,000 from the National Academy of Science for

radio wave absorption study of the upper atmosphere to be made during the coming International Geophysical Year (IGY). Prof. Rayton will establish observation stations at Hanover and at Knob Lake, Que., Canada, to study the absorption of "cosmic noise" by the earth's upper atmosphere. He will tune in on the Milky Way and measure fluctuations in radio signals received from the galaxy of which the solar system is a part.

As one of the research programs during the IGY, which runs from July 1, 1957, to December 31, 1958, physicists will be trying to get a better idea of the causes and the geographical extent of regions of high absorption. The Antarctic, for example, has its own "Southern Lights" (Aurora Australis), but physicists do not know whether conditions that produce the Northern Lights also produce the Southern Lights simultaneously.

The Oak Ridge Institute of Nuclear Studies. Basic four-week courses in the techniques of using radioisotopes will open on August 6, Sept. 3, and Oct. 22, 1956; Jan. 7, and Feb. 4, 1957. Two-week courses in veterinary radiological health for members of the armed forces veterinary corps will open on Sept. 17, Oct. 1, and Dec. 3, 1956; Mar. 4 and Mar. 18, 1957.

Institute for Defense Analyses. Massachusetts Institute of Technology is one of five institutions participating in establishment of an agency for military problem research. The non-profit agency will conduct scientific analyses of present and future weapons systems for the Weapons Systems Evaluation Group (WSEG), which functions under the direction of the Assistant Secretary of Defense for Research and Development and which provides comprehensive, objective, and independent analyses and evaluations of present and future weapons systems.

Evening Graduate Course. The subject of the controlled production of energy by thermonuclear fusion is to be given by Stevens Institute of Technology. The 15-week course, "Thermonucleonics," will cover theory, proposed processes, techniques, and problems involved in making use of energy generated in a thermonuclear reaction.

Graduate Electrical Engineering Study Program. Duke University will inaugurate a new program of graduate study in electrical engineering at the Graduate School of Arts and Sciences in the College of Engineering Extension. The program will lead to the master of science degree with a major in electrical engineering. Graduate-level courses will begin with the opening of the 1956–57 academic year. Twenty-four semester hours of graduate course work and six hours of thesis research will be required for the degree.

Training and Education of Foreign Nationals. The Argonne National Laboratory, in cooperation with North Carolina State College and Pennsylvania State University on April 16, 1956, initiated a third course in the International School of Nuclear Science and Engineering under auspices of the AEC. The 62 students included 47 selected from 23 foreign countries and 15 from the United States. These arrangements will permit increasing the number of students.

Manpower Needs. To help meet the need for graduate training in nuclear sciences the AEC supports graduate schools on a limited basis, and operates two special graduate schools—Oak Ridge School of Reactor Technology, and International School of Nuclear Science and Engineering, Argonne National Laboratory, Lemont, Ill. In April 1956 the program was changed to provide for participation of Penn State and North Carolina State, both of which have nuclear reactors. Students now take a semester of work at Penn State or North Carolina, then take an advanced semester at Argonne. Argonne physical limitations, allow only 60 students in residence. The co-operative plan enables Argonne to accept 120 students each year.

Atomic Submarine Engine Runs 66 Days at Full Power

Successful conclusion of an unprecedented power demonstration by an atomic ship propulsion reactor was announced by the U. S. Atomic Energy Commission (AEC) recently.

The nation's first practical reactor power plant—the land-based prototype of the submarine *U. S. S. Nautilus* at the Commission's National Reactor Testing Station in Idaho—was routinely shut down at the end of what is believed to have been the longest full power run ever completed by any type of propulsion plant—land, sea, or air.

On a single charge of uranium fuel (and using only part of that charge), the nuclear reactor located at the desert test facility operated at an average power of 100 per cent for more than 66 days and 66 nights. The test was designed to prove the reliability and stamina of pressurized water reactors for ship propulsion. The prototype of the reactor now in the *Nautilus* met the most demanding requirements that could be placed upon it.

At the end of the 1,600-hour test, the reactor still had many hundreds of hours of full operation available and it has resumed operation at varying power levels to obtain engineering test data and to train the U. S. Navy's atomic ship sailors. These trainees, officers, and men, will man future atomic power ships of the fleet.

The test demonstrated the feasibility of nuclear power ships cruising at high speeds and without refueling for periods of time hitherto unattainable. Among the important benefits of the test was the obtaining of essential and heretofore unavailable information on reactor performance during extended high power runs. This data will be used in the design of improved nuclear propulsion plants both for naval vessels and civilian nuclear power plants.

To indicate the significance and magnitude of the operation, it was pointed out that if the *Nautilus* itself had made a cruise for this length of time—1,600 hours—she could have steamed at top speed, submerged, around the world and many thousands of miles more. For example, she could have left the New London, Conn., Submarine Base, steamed around Cape Horn, S. A., across the Pacific, across the Indian Ocean, around the southern tip of Africa, returning to the starting point; and then continued for an extensive Arctic cruise before the scheduled shutdown.

If such a cruise had been made by a diesel-power submarine of similar power, about 1.6 million gallons of fuel would have been required. This amount of oil would fill 160 railroad tank cars, making a freight train more than one-mile long.

During the 66 days and nights of the test, Navy men assigned to the Naval Reactors Facility at the Idaho installation manned the submarine prototype plant in round-the-clock watches just as if they were in the *Nautilus* on a cruise. While the Navy ran the nuclear plant, engineers of the Westinghouse Electric Corporation which developed and built the reactor studied its performance and gathered data.

The history-making prototype first produced power in May 1953. Since that time, it has been used to supply data and advance the technology of pressurized water reactors. It was refueled in March 1956, after two and a half years' operation on the original uranium charge.

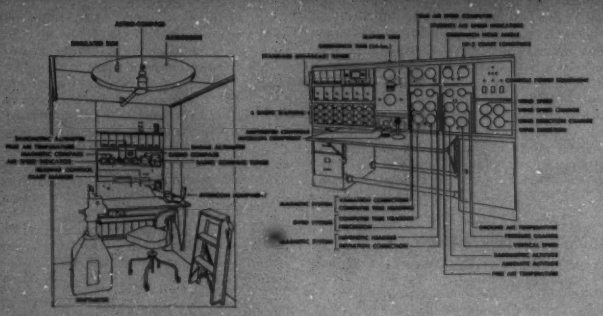
Navigational Trainer Developed for U. S. Air Force

A navigational flight simulator (the *N-3*) newly developed in conjunction with the U. S. Air Force, under a contract awarded by the Air Material Command, Wright-Patterson Air Force Base, Dayton, Ohio, was demonstrated by the Reflectone Corporation of Stamford, Conn. The *N-3* trainer provides for 13 navigator-students to be trained simultaneously in a series of identical booths which contain all the equipment with which the navigator would be faced when in flight.

The booths are controlled by an instructor-operator from a central console, through which he can set up an infinite variety of conditions for each trainee. The only device present in the *N-3* trainer which is lacking at his station in the airplane is a heading control which permits the trainee to control the "flight" of the plane in any horizontal direction. From the point of view of economy, where prior navigational training resulted in "freezing up" actual aircraft, this trainer frees such aircraft for full duty. Since the *N-3* operates at an electricity consumption cost of about $1.00 an hour as compared with the estimated cost of flying a *B-52* for an hour (several thousand dollars), the savings are extensive.

At the console, the instructor-operator sets up a large number of conditions which would be encountered by the navigator eventually, but which might not occur for weeks or months were nature to be relied upon. Thus, the console provides for controls which set up factors of wind speed, wind speed change, wind direction, and wind direction change. The Greenwich hour angle is determined by the instructor as is the longitude of the UP-2 chart. Use of the UP-2 chart, which covers a large part of the continental United States, lends a further air of realism to the simulator—students are not "flying" over theoretical terrain but over what will become usefully familiar territory.

Among the other devices at the console which are used to create conditions are free-air and ground-air temperature indicators, absolute and barometric altimeters, pressure setting, pressure change, and vertical speed. With the air-speed computer and students' air-speed indicator, certain conditions which are set up on the console are translated to the student through the instruments in his booth. The *N-3* also allows for both magnetic and gyrocompasses, with variation and deviation correction controls and magnetic heading dials to create certain conditions for the



IDENTIFYING SKETCH of trainee's booth (*left*) and of instructor's control console (*right*) shown in the picture at the bottom of this page.

former and a precession rate dial for the latter system.

An unusual feature of the trainer is its six radio stations. Each station can be positioned anywhere on the UP-2 map within a matter of seconds; each emits any one of three individual signals on adjustable frequencies—the so-called coded "beam" signal, a standard broadcast signal, or, if the instructor desires, he may speak over the radio station. Within the trainees' booths, radio compasses accurately simulate the methods used to triangulate by means of these transmitters. Once a station has been "passed" in "flight," it can be repositioned again and again by the instructor.

In order to increase the realism of the simulator, an error signal, which may be turned ON or OFF at the will of the instructor, was wired into the radio-compass circuit. It was found that the smooth, tremorless "flight" of the simulator was not matched by the rougher, more deviating action of true flight; since this vibration causes the radio compass dial to waver, making it difficult for the navigator in true flight to pinpoint his position with absolute certainty, for the sake of realism, such an error signal was installed in the *N-3*, resulting in the same difficulty for the student.

Another touch of realism is encountered in the radio station setup. In actual flight, when between transmitting stations, the signal is somewhat garbled and a considerable amount of static results until the stronger signal (the one being approached) reduces the static to a minimum. This has been simulated in the trainer and, when the student is between stations, he hears realistic static as in true flight.

The instructor has controls which adjust the driftmeter readings within the trainee booths, a 24-hour clock indicating Greenwich Time, another clock indicating elapsed "flying" time, and intercom equipment by means of which he can communicate with any one or number of the students.

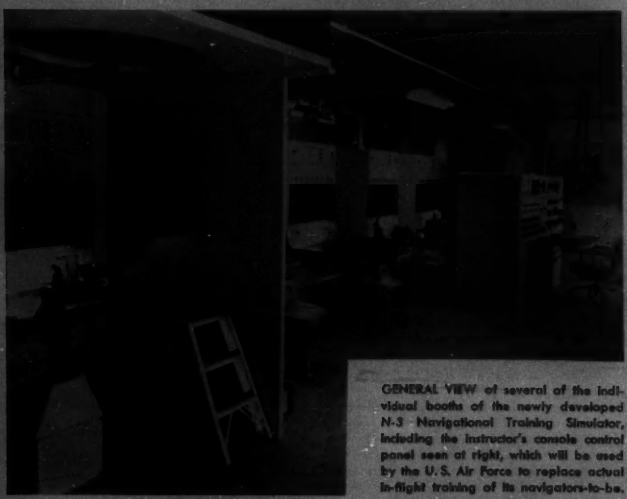
At the top of each trainee's booth is a simulated astrodome with an astrocompass fixed at its center. A "sun" revolves at the periphery of the astrodome, its position determined by the heading. Besides typical intercom equipment, the navigator's station is outfitted with a radio compass and tuner, a radar and barometric altimeter, free-air-temperature indicator, air-speed indicator, and magnetic-compass indicator. The heading control, which may or may not be released by the instructor for the individual student's use, is located on the panel near a button designated "Chart Marker."

The driftmeter, standing separately, is a highly complex device in an airplane; simulating it was a feat of engineering imagination. An aerial photograph in the form of a belt revolves within view through the eyepiece, its speed determined automatically by the conditions set up at the console. It has two eyepieces, one for low and one for greater altitudes. Its housing assumes the familiar bulge associated with the gyro-stabilizer necessary in actual flight.

On the back of each booth is a large, ground-glass panel on which is marked the UP-2 chart. A stylus, controlled by an analogue computer, traces the course of each student's "flight" throughout the problem, and it is here that the "Chart Marker" button comes into play. This marker permits the student or the instructor to mark places on the chart of his recorded "flight" to which the instructor may refer during the training session or the student at its termination. The stylus marks the true "flight" of the aircraft—that is, the product of the conditions fed into the trainer by the instructor and the decisions made by the student. Each student, in addition, keeps his own map within the booth, charting his course as he progresses. Comparison of the two at the end of the session shows where a miscalculation was made and where the student's study requirements lie.

The entire *N-3* trainer was designed for maximum ease of maintenance. Almost all units are readily servicable by token of their being in sliding chassis, which are modular and equipped with "floating" plugs of the new ribbon type. Indexing pins project in front of the electrical connectors so that incorrect drawer insertion is obviated. The six radio stations are interchangeable. Only two types of servo amplifier chassis have been used in the entire unit. In addition to its being modular, each of the 13 booths is portable. Booths are light and easy to handle, and the instrument panels are set on casters which are lifted clear of the floor by solid, positive jacks when the units are installed.

The *N-3* navigational trainer will also be installed at the Air Force Academy in Colorado as soon as the buildings there are completed.



GENERAL VIEW of several of the individual booths of the newly developed *N-3* Navigational Training Simulator, including the instructor's console control panel seen at right, which will be used by the U. S. Air Force to replace actual in-flight training of its navigators-to-be.

Recent Progress in Field of Air Traffic Control

The Civil Aeronautics Administration (CAA) will soon be gathering air traffic information electronically at Indianapolis, Ind., from widely separated radar stations in Indiana and Ohio.

The award of a $440,000 contract from Rome Air Force Depot for a 100-mile microwave radar relay system connecting Indian-

apolis, Ind., and Dayton, Ohio, has recently been announced. The CAA will use this system to develop and evaluate techniques and procedures for improvements in air traffic control.

The development program will be under the supervision of the Airways Operation Evaluation Center (AOEC), a laboratory of the CAA's Technical Development Center, located at Indianapolis. AOEC will be assisted in its efforts by the work of the Traffic Approach Control and Landing Systems office of the U. S. Air Force's Air Research and Development Command.

The microwave system will collect air traffic information from a radar network in the northern half of the Indianapolis Air Route Traffic Control Center area, a zone about 400 miles long and 150 miles wide. This system will tie in with an existing microwave network originating at the U. S. Air Force Base in Jamestown, Ohio. It is expected that the radar collection system will be expanded at a later date to obtain data from the Bellefontaine, Columbus, and Cincinnati areas of Ohio.

In addition to the radar transmission feature, the link will also provide a high capacity two-way communication system which will be used to control peripheral air-to-ground communication equipment, and which will, in the future, provide for transmission of automatically collected and processed information on air traffic movements. It will be a major tool in closer civil/military co-ordination in air traffic control development.

In Rochester, N. Y., an electronic display device to help solve air traffic control problems has been announced by the Stromberg-Carlson Division of General Dynamics Corporation. Developed at the division's plant in San Diego, Calif., the device is a commercial version of the Charactron shaped-beam tube which has been used for some time in the SAGE (semi-automatic ground environment) system of military aircraft surveillance (March 1956, *EE*).

Production has started on the model, which has a 19-inch diameter screen. The new tube will be useful both for civil and military air terminals when combined with individually engineered control panels, radar, and electronic computers to create improved air traffic control systems.

Such a system could be used to supplement present programs which utilize radar to spot the many airplanes approaching, departing, and flying over major airfields.

In addition to providing the relative positions of the aircraft and showing movement across a map-diagram, the system employing the Charactron shaped-beam tube prints letters and numbers to represent such information as flight number of the plane, speed, and altitude. All of this is superimposed on a line map-diagram of the airfield area eliminating the so-called "clutter" or nonessential geographical shapes picked by by the raw radar.

Each cluster of numbers and letters moves in the map-screen in relation to each airplane's movement in flight and the numbers and letters in each cluster change as often as necessary to provide current information. Thus, a tower operator engaged in directing air traffic can assimilate a tremendous amount of information from many radar sets, relating to many airplanes.

The Charactron shaped-beam tube which forms the heart of this system of air traffic control is essentially a device for displaying letters and numbers on a cathode-ray tube. In the tube electrons are actually "squirted" or extruded through a tiny stencil in which each opening is shaped like a letter or number to be reproduced. When the electron beams thus shaped strike the phosphor-coated screen they reproduce a visible letter on the screen. One of the advantages of the Charactron tube is the tremendous speed with which it can reproduce information fed into it through a system composed of computers, radar or other data sources.

The 19-inch Charactron tube has a capability of reproducing letters and numbers or specially designed characters at a rate in excess of 20,000 characters per second. Because each is formed by a carefully engraved opening of predetermined shape in the tiny stencil, the fidelity of reproduction of these characters is uniformly high, comparable to that obtainable in conventional letter-press printing.

Electronic "Eye" To Aid Blind PBX Operators

An electronic "eye" weighing less than an ounce has been developed as an aid to blind operators of private telephone switchboards. A tiny, light-sensitive phototransistor which fits on the tip of an index finger is the only piece of equipment which must be worn by the blind operator in addition to the standard operator's headset.

Developed by Bell Telephone Laboratories and still in the experimental stage, the device will be tried out soon by blind operators of private switchboards under the auspices of the New York Telephone Company.

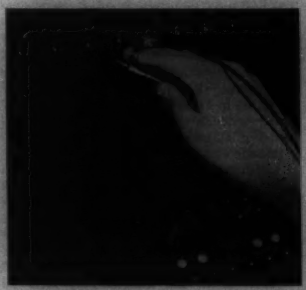
The photoelectric system is applicable to a standard PBX (private branch exchange) switchboard. It does not require any modification of the equipment, as was necessary in the past. When a call comes into the switchboard, a signal is heard and a lamp lights. There are horizontal rows of lamps, and an operator with normal vision simply plugs a cord into the jack associated with the lighted lamp.

Using the new device, when the blind operator hears the signal of an incoming call, she runs her finger, with the electronic "eye" attached to it, across the rows of lamps. Because the "eye" is so tiny, she is able to hold the cord in her hand as she hunts for the lighted lamp. When the lighted lamp is reached the phototransistor is activated and the operator hears a signal through her headset. The cord that she holds is plugged into the jack associated with the lighted lamp, thus completing the connection. The operator then determines the extension to which the caller wants to be connected, picks up another cord paired with the first one, and plugs it in to ring the desired extension. She would know the location of the extension jacks through her familiarity with the switchboard.

At one time PBX switchboards employed metal indicators (drops), which dropped from a vertical to a horizontal position when a call came in, and the blind operator could feel for these indicators.

Later, switchboard lamps were introduced for the purpose of efficiency and a new system was needed if blind persons were to continue as operators. The Bell System developed, produced, and put into operation a system using Braille-designated indicators which were wired to the lamp leads and attached to a switchboard. This modification of equipment proved costly for PBX users; therefore, Bell Laboratories undertook investigation of a simpler, less expensive device.

Although the basic concept of identifying



Bell Telephone Laboratories

ELECTRONIC "EYE" aid to blind operators of private telephone switchboards using fingertip phototransistor device which weighs less than an ounce and detects lighted lamp marking incoming call.

lighted switchboard lamps by means of photoelectric cells is not new, the Bell equipment is unique in its use of transistors, and its extremely small size and light weight. It may make possible a system that is sufficiently economical and practical for use by blind operators of private switchboards.

Research Center Dedication on International Closed Circuit Telecast

Dedicated to "a better tomorrow through research today," the 25-building Technical Center is the General Motors Corporation challenge to the technological advance of America.

The giant industrial research center near Detroit was dedicated by General Motors (GM) on an international closed circuit telecast climaxed by a personal television message from President Dwight D. Eisenhower.

The President spoke over a special network extending to 61 cities in the United States and Canada where more than 20,000 General Motors executives and their guests gathered at luncheon meetings commemorating the dedication.

More than 5,000 distinguished leaders in industry, business, the sciences, education, Government, press, radio, and television from throughout the nation participated in the event at the Center itself.

Speaking from the White House, the President's address was fed into the telecast originating from Detroit. Pres. Eisenhower

was introduced by GM president H. H. Curtice.

The program included a television tour of the grounds where almost 5,000 scientists, engineers, and technicians are at work. Major addresses which preceded the President were made by Mr. Curtice; Dr. L. R. Hafstad, GM vice president in charge of research; and C. F. (Boss) Kettering, research consultant.

On display in the five staff building groups—Styling, Research, Engineering, Process Development, and Service—were typical examples of what goes on "within the walls" of the Center.

The Center has a campus-like atmosphere. The buildings, none over three stories, are an architectural fantasyland of steel, aluminum, glass, and multicolored glazed brick.

They cluster around a 22-acre artificial lake where breath-taking fountains spurt more water than the famed fountains of Versailles in France. The quiet grace of its modern design has made the Center a model of industrial architecture.

But the Center is something more. From its talented scientists, engineers, technicians, and stylists come products and processes which touch every home—medicine, kitchens, air conditioning, automobiles, trucks, earth movers, military vehicles, aircraft engines, bearings, paints, and fabrics are only a few.

Some excite the imagination, such as GM's latest experimental automobile, the *XP-500*. The world's first car powered by a "free piston" engine, the *XP-500* may be a guidepost for highway travel of the future. It also was on display at the Center for guests attending the dedication.

Receiving Tube Wired Directly into Electronic Equipment

A completely new concept in electronic receiving tube manufacture was revealed recently when Eitel-McCullough, Inc., of San Bruno, Calif., released information on a new Eimac stacked ceramic receiving tube. The company, one of the largest manufacturers of power transmitting tubes, developed the new tubes under an Air Force contract to provide a small electronic tube which would withstand environments found in airborne and missile applications.

The outstanding features of the tubes were achieved by breaking away completely from ordinary concepts of tube design. The life of the new tubes is so long that they will be wired directly into electronic equipment, thereby eliminating the need for tube sockets. Also, their design permits them to withstand heavy accelerative forces from shock and vibration, and to operate continuously with envelope temperatures of more than 300 C without deterioration of electrical characteristics.

At the present time, Eimac has released information on four of the miniature tubes—two production models, and two development models. The company plans to develop a complete line of tubes which will meet most receiving requirements with a minimum number of tube types.

The four tubes now going into production are the *33C3A2*, a twin-triode amplifier; the *5C2A*, a sharp-cutoff pentode; and two developmental tubes: the *CD-19*, a medium-μ triode; and the *CD-22*, a beam power amplifier.

The recent demonstration included a ten-minute color film, "Tubes That Can Take It," describing various applications of the new tubes, and methods of their manufacture. In addition to developing the tubes, Eimac is now completing pilotline automation equipment to produce the new tubes.

Dial Telephone Transistorized Switchboard

A transistorized all-electronic dial telephone switchboard which uses no vacuum tubes or mechanical stepping switches has been completed by Stromberg-Carlson, a division of General Dynamics Corporation, and delivered to the Bureau of Ships of the United States Navy.

In this switchboard, all line finding, circuit switching, tone signal generating, and virtually all functions found in conventional dial switching systems, are performed by transistors or diodes. This is the first such complete transistorized switchboard publicly announced in this country.

Work on electronic switching systems was initiated by Stromberg-Carlson more than eight years ago. In the early years of this research program, all switching was accomplished by combinations of conventional vacuum tubes, special gas tubes, and electromechanical devices. Systems incorporating such devices were large, heavy, consumed a great deal of power, and dissipated large amounts of heat.

However, circuits that were worked out for such electronic systems were readily adaptable to use with transistors when those devices became available, and Stromberg-Carlson incorporated transistors into its experimental electronic switching systems.

At this stage the development was shown to various military agencies, and as a result the Bureau of Ships' interest in the work culminated in a developmental contract for a 100-line switchboard.

Work has been in progress on a prototype 100-line, 15-link electronic switching system for a shipboard installation for the U. S. Navy. This 100-line system will require approximately 4,500 transistors and 5,000 diodes.

The transistorized switchboard provides a number of significant advantages over the electromechanical switching systems now in general use. It is compact, and lightweight, requiring less than half as much space as existing models. It weighs about one fourth as much as a typical electromechanical dial system. These factors are especially important in shipboard installations, where space and weight must be kept to a minimum.

The transistorized switchboard has been designed and built for compatibility with other United States telephone equipment. Thus, it can be used in conjunction with any other telephone systems or equipment in this country.

Saucer Over Ventnor Is a Television Antenna

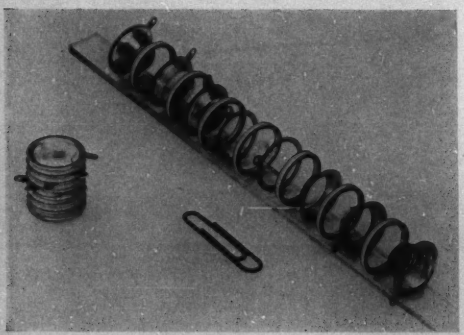
There is something new in the air over Ventnor, N. J. It is a giant television "dish" antenna which sits atop two 100-foot steel towers and beams in signals from over 100 miles away.

The "dish," or paraboloidal antenna, was build by Jerrold Electronics Corporation of Philadelphia, Pa., manufacturer and pioneer of wired television distribution systems, to experiment in pickup of New York channels. It is the largest paraboloidal antenna known to have been built for use in a community antenna system. Experimentation is being carried on in conjunction with the South Jersey TV Cable Company, community antenna system serving Ventnor. Programs picked up by the "dish" will be fed into the system from time to time.

The Ventnor system now receives three channels from Philadelphia (3,6,10) and one (12) from Wilmington, Del. These signals are picked up on an antenna tower outside the city and are carried to subscribers' homes by means of coaxial cable strung along telephone poles.

The 3,500-pound "dish" structure—which is as tall and as wide as a $2^1/_2$ story house—hangs on two hinge pins from the upper brackets of the 100-foot supporting towers. Lower end of the frame is adjusted by two screw-operated devices to tilt the antenna in operation. This allows the "dish" to be angled for pickup of maximum signal.

Having a diameter of 26 feet, the "dish" was hung 100 feet up in the air so that it would not bend or turn in the Atlantic gales of the eastern seaboard. It can withstand 80-mile winds with 1/2 inch ice coatin g.



EXPLODED VIEW of an Eimac 33C452 dual triode stacked ceramic tube, typical of the newly developed concept in receiving tubes.

Radio Telescope Measures Sun's Atmosphere

A radio telescope developed recently will soon begin the task of exploring the sun's turbulent atmosphere. The Air Research and Development Command's (ARDC) Air Force Office of Scientific Research has financed the construction of this new apparatus, after conception of the idea by Stanford (Calif.) University.

Called a microwave spectroheliograph, the device will carry on its explorations from an observation point on the Stanford University campus. It consists of 32 parabolic aluminum antennas, which will be aligned in two rows to form a huge cross occupying a level, two-acre meadow.

Under the direction of Professor R. N. Bracewell of Stanford's Radio Propagation Laboratory, the device will pick up solar microwave radiations in the 3,000 megacycle region.

As the dish antennas scan the sun's surface in the same way a television camera scans its subject, the photograph produced shows the chromosphere—a hitherto mysterious billowing layer of incandescence, rising to heights of 6,000 miles above the sun's surface.

Although discovered many years ago at the time of solar eclipses, little is known about the chromosphere. The development of radio astronomy in the postwar era has renewed efforts to unveil its secrets. It is believed to have some connection with sunspots, which in turn are related to magnetic storms which interrupt radio communications.

The 32 antennas will look straight at the sun, scanning its surface in unison, and following automatically as it crosses the sky. A photograph of the entire solar orb will be completed in about two hours. Clouds will not affect antenna efficiency.

A primary accomplishment will be the scanning of solar regions as small as three-thousandths of one square degree, a definition finer than ever before achieved in radio astronomy or in radar.

Dr. Bracewell has recently served as a research officer with the Commonwealth Scientific and Industrial Research Organization at Sydney, Australia, a world center of radio astronomy research.

Shells and Pits Remove Enamel from Wires

A novel kind of shell game is boosting factory production for a Minnesota manufacturer, it was recently reported.

To remove enamel from hair-thin wires used in electrical coils for thermostats, inventive engineers at Minneapolis-Honeywell bombard the coils with finely ground pecan shells and apricot pits. The flying grit does the job at a fraction of the cost of chemicals or other more conventional burnishing methods.

The new system is faster too! Production of the elements now runs at a rate of 1,000 an hour. Best previous rate, by routine enamel-removing operations, was 1,000 a day.

For other, more sensitive wire coils, powdered corn cobs are used in the machine.

Experiment Reactor for Low-Cost Nuclear-Fuel Electricity

A new type of experimental atomic energy reactor to develop low-cost electricity from nuclear fuel will be designed and built by Atomics International, a division of North American Aviation for the Atomic Energy Commission (AEC), it has been announced.

The reactor will be built at the AEC's National Reactor Testing Station in Idaho.

A small experimental unit and a part of the AEC's program for developing economic nuclear power, the unit is known as the Organic Moderated Reactor Experiment (OMRE). It will involve an expenditure of $1.8 million. Atomics International is assisting by bearing approximately $750,000 of this cost.

An organic material, a carbon-hydrogen compound such as diphenyl, will have the dual role of "moderator-coolant" in the reactor system. As a moderator, the material will "slow down" neutrons produced in the atomic fission process, helping to sustain the chain reaction. As a coolant, the organic material, which will be in a liquid state while the reactor is in operation, will circulate through the reactor core where heat from the fission process will be "soaked up" and carried outside to heat exchangers.

About 16,000-kw power in the form of heat will be produced by the reactor. The conversion of this heat into electricity is not comtemplated, as the experimental program will be concerned only with the technologies of the reactor itself.

The core will consist of plate-type fuel elements containing U-235 and the organic coolant. Use of diphenyl offers advantages which stem from the inherent properties of the material, such as: (1) high hydrogen content, which makes it an excellent moderator; (2) relatively high temperatures compared with water, so there is no need to maintain the compound under high pressures; (3) negligible corrosion with standard materials of construction; (4) does not react readily with uranium; and (5) only slightly radioactive upon exposure to nuclear radiation.

Problems to be solved are concerned chiefly with the effect of heat and radiation on the organic coolant, which tends to deteriorate. The primary purpose of the OMRE is to determine irradiation and thermal stability of organic coolants under conditions found in a prototype power reactor.

Computer for Radioactive Fallout

A special-purpose computer that gives the geographical fallout pattern of radioactivity resulting from a nuclear explosion has been developed by the National Bureau of Standards. Given the necessary weather data together with certain information about the bomb, this analogue computer will assist in predicting what the distribution and intensity of radioactivity will be on the ground after the bomb has been detonated. Problem solution is displayed on a cathode ray tube, over which a map on a transparent backing can be laid. Radioactive intensity at any ground point up to 500 miles from the explosion can then be measured by the brightness at the corresponding point on the tube screen. The computer was developed for the United States Weather Bureau and the Atomic Energy Commission by H. R. Skramstad and J. H. Wright of the Bureau's analogue computers laboratory.

Safety is a prime consideration at the nuclear bomb testing grounds. Precautions are taken in advance of a test to prevent radioactive material from falling on inhabited areas. Such precautions require information about the bomb as well as an intimate knowledge of the weather pattern, and from these data extensive calculations determine the fallout pattern. In the past, fallout predictions have required the laborious hand calculations of a team of mathematicians for 1/2 hour or more for each prediction. The use of high-speed electronic digital computers eliminates most of the manual effort and reduces the calculation time to 15 minutes. However, these high-speed computers are usually large, permanent, and expensive installations. To provide even faster predictions with portable, relatively inexpensive equipment, the Bureau developed a computer that does not require highly trained personnel for its operation. The machine uses electronic analogue techniques to complete the computation almost instantly after the data are inserted. Subsequent changes in weather data can easily be inserted into the machine as rapidly as the operator can set the appropriate knobs.

In its use at an atomic proving ground, the new computer will provide the test manager with immediate knowledge of the effect of any changes in the winds. For civil defense, the computer can be used in research studies or in case of an actual attack. Forecasting could be expected to help determine and speed up the emergency procedures to be used after a bomb explosion, with a consequent saving in lives.

The prototype computer is contained in two 6-foot relay racks, including power supplies and one oscilloscope. A 21-inch display oscilloscope is mounted separately. About 106 tubes and 58 silicon junction diodes are used in the equipment, excluding power supplies and oscilloscopes. The total power requirement is about 1,500 watts. Data are fed into the machine simply by adjusting approximately 80 knobs on the front panel; 40 of these knobs correspond to wind speeds and directions.

Although this is not a simulation analogue computer, it uses analogue techniques to mechanize the fallout problem. In particular, time in this computer is used for sequencing only and has no direct significance in terms of the time variable in the original physical model.

Hydraulic Oil Circuit Breaker Tank Lifter

An economical hydraulically operated tank lifter, which substantially reduces time and labor involved in raising and lowering oil-filled tanks of frame-mounted, outdoor oil circuit breakers, has been developed by Allis-Chalmers Manufacturing Company.

The lifter consists of two cylinders con-

taining pistons and a length of flexible hose with quick disconnect couplings. It can be operated directly from the "Pneu-Draulic" operator of the breaker, or from a portable battery powered pump. When operated from the breaker, it connects to the breaker's hydraulic system through a small door in the side of the breaker cabinet. From this vantage point, it is possible to have a complete and unobstructed view at all times.

Two manually operated needle valves control the raising and lowering of the tanks which can be safely stopped at any point. An orifice in each cylinder limits the maximum speed at which the tank can be lowered or raised. Should a hydraulic hose or fitting be removed or broken during operation, the tank descends at normal speed until completely lowered. The accumulator of the "Pneu-Draulic" operator contains enough energy at normal operating pressure to raise and lower all three of the breaker's tanks without requiring recharging.

Cylinders of the tank lifter are attached to the breaker frame by removing two opposite tank bolts and inserting the cylinder ram through the tank and frame bolt holes. The nut is threaded onto the ram and pressure applied to the cylinders. This pressure supports the tank tightly in the "up" position while the other tank bolts are removed. Pressure within the cylinder is then released by means of the exhaust control valve and the tank is lowered at a controlled speed.

In raising the tank, pressure is allowed to enter the cylinder by means of the pressure control valve. The tank then rises at a controlled speed to the "up" position where it is supported by pressure within the cylinders while the tank is bolted securely. The pressure is then reduced and the cylinders removed. An oil-filled tank can be completely raised or lowered within 40 seconds after the operation has been initiated.

The portable battery operated hydraulic tank lifter is designed for use with solenoid and pneumatic operated intermediate capacity, outdoor oil circuit breakers. It consists of a small piston-type pump driven by a standard, 120-ampere hour, 6-volt battery through an automobile starter motor, together with a reservoir and by-pass valve. It is capable of raising and lowering the tank 60 times at normal speed without recharging.

RADAT Pilot Model Delivered to U. S. Navy

An electronic system, which automatically plots on a central control scope, radar images plus identification and pertinent data transmitted by telephone from distant radar stations, has been developed for the Bureau of Ships, United States Navy, by Skiatron Electronics and Television Corporation.

The principles involved have far-reaching civilian applications, as well as military and civil defense purposes for which the system was developed.

Known as Radar Data Transmission System (RADAT), the pilot model has been delivered to the Naval Research Laboratories.

Made possible by development of Skiatron's unique Data Inserter (DATIN), for the first time, it is practical to superimpose a code signal or other data upon a radar image and transmit the combined intelligence automatically to any central office reached by a telephone.

With existing equipment, it was explained, the operator of an outlying radar station reports a target appearing on his scope by telephone. This permits several chances for human error, as well as confusion, as reports come into headquarters from several stations at once.

With RADAT, however, headquarters will see upon its own scope both the radar intelligence received by the station plus necessary data supplied by the operator. In addition to reducing elements of human error to a minimum, it takes off a tremendous load of detail work from Central Control, freeing it for the all-important role of speedy command decisions.

Outstanding among probable civilian applications is an entirely new concept of weather reporting which RADAT now makes feasible.

How Much Bounce in a Spring?

To answer this question and to provide for customers a more accurate evaluation of other wire products, United States Steel Corporation's American Steel and Wire Division has established at its Cuyahoga Works, Cleveland, Ohio, the only laboratory in the corporation devoted exclusively to fatigue testing.

Fatigue testing simply is determining the life span and endurance limits of steel products. To this end, the Cleveland Laboratory is one big torture chamber for springs, cables, wire rope, conductors, and other products made of wire.

For testing helical springs such as automobile valve and front suspension springs, springs for beds, machine guns, railroad cars, and for refrigerator compressors, the laboratory is equipped with 4 variable stroke compression machines, one of which is able to test springs made of 3/4-inch diameter wire and having a compression up to 7,500 pounds. This machine tests two springs at a time and has a variable speed up to 1,500 cycles per minute.

In a high wind, transmission cables will "sing" as they vibrate. This vibration of the cable causes it to flex rapidly at all points of support. As these cables are installed for decades of service, the wire must be designed to withstand this flexing action. The Laboratory has two vibration machines to simultate, through electromagnetic drive, the action of wind vibration from 1 cycle to 20,000 cycles per second.

Two torsion spring testers are provided to evaluate springs such as are used in overhead garage doors, wind-up toys, and various other spring-powered equipment. These machines can cycle each spring through any range suitable to determine its life expectancy and load-carrying capacity.

Of the laboratory's two tensile-strength machines, one is unusual. It is horizontal instead of vertical and can take up to 20 feet of sample cable. It has a maximum capacity of 60,000-pounds pull.

There are four reverse-bending machines for testing wire from 1/4-inch in diameter down to 0.004 inch. The wire to be tested is mounted in a curve and then rotated at speeds up to 20,000 revolutions per minute. The wire is run to destruction or to 10 million cycles. Under such reverse stress, it has been found that if the steel can stand up to 10 million cycles, it will withstand almost an infinite number of such stresses. All the machines in the fatigue laboratory, running day and night, automatically record cycles and automatically shut off when the sample test piece fails.

The fatigue laboratory, which operates as part of the metallurgical department, also serves in developing new products. For instance, when airplane manufacturers expressed the need for control cable with expansion characteristics to match that of the aluminum aircraft frame, various metallurgical formulas were tested and modified in line with the laboratory's recommendations. From the joint efforts of testing and metallurgy came a new application of a steel alloy that when fabricated into cable became the well known Hyco-span aircraft control cable with nonmagnetic qualities and a coefficient of expansion closely approximating that of aluminum alloys used in aircraft construction.

More recently, the laboratory performed a series of load-strain and fatigue studies on galvanized bridge wire. From these studies, engineers were guided in the selection of wire for the cables on the new Delaware River Bridge near Philadelphia, Pa., and on the great span across the Mackinac Straits, Mich.

Flight Control Bomb Systems in U. S. Superbombers "Most Deadly"

An electronic system permitting the newest strategic bombers to find and destroy unseen enemy targets, with unprecedented accuracy, was revealed recently by the United States Air Force (USAF) and the Sperry Gyroscope Company of Great Neck, L. I., New York.

The system—actually two—combines a specially developed Sperry *A-14* automatic flight control system and an *MA-6A* electronic bombing system, incorporating further improvements over the K-bombing navigation system designed previously by Sperry for the huge *B-36* and all-jet *B-47* bombers of the Strategic Air Command (SAC).

Both of the critical subsystems are being installed in the new Boeing *B-52* Stratofortress. The eight-jet superbombers now are being delivered to SAC for operational use.

Almost fantastic capability and accuracy of the new intercontinental bomber is described by Air Force Secretary D. A. Quarles as the ". . .most formidable expression of airpower in the history of military aviation."

"Its range, bomb load, and highly skilled crews, coupled with electronic equipment which enables its crews to find and hit any target anywhere in the world in any weather, constitute a weapons system which no other nation can match," it was stated by Secretary Quarles.

Designed by Sperry to Boeing and Air Force specifications, the *A-14* flight system

provides precision control during long hours of approach to distant targets, supplies automatic control by the bombardier, and aids in instrument landing.

The so-called "electronic co-pilot"—a far cry from conventional autopilots of past years—helps the pilot control a nuclear bomber with ease and efficiency at both minimum and maximum flight operation ranges, or anywhere between. It is designed to "change gears" or compensate for differing control requirements at various flight speeds and altitudes.

This new development, called parameter control, automatically determines how much or how little force should be applied to the Stratofortress' control surfaces (ailerons and rudder) to obtain the maneuver desired by the pilot or bombardier under varying flight conditions.

Engineers, in designing this "near-human" system, took into account the "bending" or flexibility of the Stratofortress' 156-foot-long fuselage in establishing the degree of control required to accomplish a flight maneuver safely and accurately, the USAF said.

An automatic cut-off has been designed into the flight control system. This safety feature continuously compares signals from accelerometers with the direction and magnitude of the control effort. It disengages the electronic system whenever control signals call for forces in excess of that which is required for the flight condition that exists at that time.

Another feature is the location of a master command-selector panel and flight controller between the aircraft commander and pilot stations. This puts within easy reach of both officers all switches required to engage and turn off the system, control altitude and turns, and "automatically fly" the Stratofortress during an instrument landing approach.

All switches are suitably interlocked to prevent accidental selection of incompatible modes of operation.

The very advanced *MA-6A* bombing system, utilizing target data obtained either optically or by radar, automatically "feeds" steering information to the automatic flight control system as the bombardier makes the necessary commands. This, in turn, controls aircraft action required to maintain a desired course and altitude throughout the entire flight.

The bombing system allows a *B-52* to take evasive action to avoid enemy aircraft and ground fire while on the bombing run, thus eliminating the straight-and-level approach method that once made strategic bombers vulnerable to this type of enemy defense.

Aided by these versatile subsystems, the Stratofort's bombing team unerringly can guide the superbomber to a predetermined, precise pinpoint in space at which a bomb must be released to strike the target at which it is aiming.

This proved capability of the systems permits SAC's nuclear bombers to take off from a base in this nation, locate and destroy a target thousands of miles distant, and return to base.

Thus, these systems strengthen our nation's first line of defense and contribute to the defense and welfare of the free world, it was stated by the SAC.

Sonic Pictures Diagnose Illness

The day when sonic pictures of man's insides might be used to diagnose and treat illness has been brought a little closer to possibility by research in the use of high frequency sound waves for picture formation by a research team at the Polytechnic Institute of Brooklyn.

E. E. Suckling, a doctoral student in electrical engineering, and Prof. W. R. MacLean have used ultrasonic waves in the same way that photographers use light, and evolved a method for the translation of the waves reflected from the object being "shot" into pictures on a television-like screen.

Because they do not use reflected light rays to capture the image being "photographed," they can work in dark places, such as the innards of men and animals, and still get a picture.

At the present time, pictures taken with sound show with relative clearness the outlines of such delicate structures as a fish skeleton, a cat's kidney, and the bone structure in the human hand. The technique also shows promise of being able to pick up and picture such X-ray transparent structures as the pancreas.

Sound waves have the characteristic of being reflected by objects as small as the length of the wave itself. Therefore, the one fiftieth of an inch high-frequency wave being used has the capacity to be reflected, and therefore translated into a picture, by an object of that relative size, either in width or depth. As a result, the possibilities for picturing nerves, veins, arteries, and small lesions are also definitely present.

Another possible advantage of the sonic picture technique is the fact that, unlike X-rays which must pass completely through an object being studied and which throw shadows of everything through which they pass, sound lenses can be specifically focused for a certain depth and will send back only information from that depth.

The high frequency sound employed in the process, one fiftieth of an inch as compared to the two inches or so of ordinary audible sound, must be transmitted through water. When sent through the atmosphere it disappears among the oxygen atoms. Objects being photographed by sound at the present time, therefore, must be immersed in water.

Since the sound waves can pass through the object being studied, a picture gained through transmission rather than reflection could also be formed.

In an experiment with a cat, for example, the animal's body was suspended in a tank. In the corners of the tank, facing the parts to be pictured, piezo electric quartz crystals were placed, just like floodlights, which sent high frequency sound waves to the animal, to be reflected back in the manner of all waves.

The reflected waves were caught by a sonic lens, a device which reassembles the sound waves and transmits an image-in-sound in the same way that a camera lens treats reflected light.

The sonic lens then focuses the sound image onto a single transducer crystal which converts the sound to an electric field whose variations exactly duplicate the sound image being reflected from the object. A capacity scanner, designed and developed by Professors Suckling and MacLean, then picks off the electric field from the crystal and relays the electric impulses, as in television, to the oscilloscope screen where they form a picture. The development of the transducer, the electronic device which translates the sound wave phenomena into the visible picture is the team's principal contribution to this area of study.

Other scientists have utilized the familiar naval sonar technique to develop visual images. In this method, a single shaft, or pencil, of sound is used to scan the object being studied and from a large number of reflections a reconstruction of the object is made.

The method developed by the Professors enables the subject to be "photographed" as a whole almost instantaneously, and to be studied as a picture almost at the moment of photographing. Eventually, as work progresses, movement may be shown as they occur.

Fresh Flavors Restored to Processed Foods

Restoration of fresh natural flavor to foods after processing has been accomplished in a novel and important advance in the food field. The new technique was announced recently by scientists of the United States Army Quartermaster Research and Development Command, Natick, Mass., and Evans Research and Development Corporation, chemical consultants, New York, N. Y. Describing the research to the annual meeting of the Institute of Food Technologists, the team of scientists from the consulting laboratory and the Government laboratory revealed that enzymes could be used to release latent flavor locked up in many processed foods in the form of flavor precursors.

The research team consisted of Dr. Torsten Hasselstrom of the Quartermaster laboratory, and Dr. E. J. Hewitt, Dr. D. A. M. Mackay, and Dr. K. S. Konigsbacher, of Evans Research.

These scientists have been engaged in a program of research in which one of the objectives was to make dehydrated cabbage more palatable for use in feeding Armed Forces personnel. In their report to the convention of food scientists, they described experiments in which the natural fresh flavor of raw cabbage was restored to dehydrated cabbage by treating it with water and an enzyme preparation made from mustard seeds.

The process, however, is not specific for cabbage. Fresh watercress was blanched in steam and dehydrated in an oven. The flavorless product had none of the characteristic taste and smell of watercress. On adding water, the rehydrated watercress smelled and tasted like hay. When an enzyme preparation from mustard seeds was added, the typical odor and taste of fresh watercress were quickly regained.

The general applicability of the process has been shown by making flavor improvements in such diverse processed foods as peas, celery, leek, spinach, pineapples, onions, tomatoes, oranges, bananas, parsley, strawberries, milk, and carrots.

In describing their research, the scientists emphasized the necessity for finding suitable sources rich in the enzymes necessary for each particular food. They also pointed

out that the processing of the food must not be so severe as to destroy the flavor precursors that are essential to working of the process.

"Sixth Sense" Instruments Control Chemical Manufacturing

Special instruments equipped with a "sixth sense" have been designed by General Electric Company engineers to help control complicated chemical manufacturing processes at the Atomic Energy Commission's (AEC) Hanford plant.

R. J. Brouns, General Electric chemist employed at Hanford described two such "sixth sense" instruments in a paper presented before the 1956 General Electric Analytical Conference in Schenectady, N.Y. General Electric operates the Hanford plant for the AEC.

Both instruments measure properties of chemical solutions continually during production runs, helping operating engineers to keep close control over results and to obtain a uniform operation. Data from the instruments is available for immediate use and process correction. Formerly, several hours were necessary to obtain analytical results from laboratory tests.

One of the instruments described uses a by-product of plutonium production as an aid in gathering data necessary to control that production. Atomic rays given off by a radioactive isotope are used to measure properties of materials under processing. By measuring the amount of radioactivity absorbed by the material, technicians can determine changes in the flow of materials under process.

Another instrument adapted by the engineers for their own purposes uses a light bulb for its yardstick and a photoelectric cell as a measuring device. The light is filtered to select the wavelengths best suited to the measurements wanted. The amount of light passing through the filter is known to technicians and the amount that reaches the cell after passing through the material to be measured is reported on an electronic recorder. The light absorbed by the material under process is the "key" to the property to be determined.

This device has been designed with an eye for use in measuring radioactive materials. Its advantages are found in being cheap, virtually unbreakable, acid and fume resistant, and in the fact that it can be installed quickly. The control unit for the sensing device can be located some 50 to 100 feet away.

Atom-Powered Planes Industrial Future of Georgia

Atom-powered airplanes have zoomed into the No. 1 spot in Georgia's potential industrial future in a series of rapid developments which have mushroomed like the cloud from an A-bomb.

Three announcements—two by Lockheed Aircraft's Georgia Division at Marietta, Ga., and one by Georgia Governor Marvin Griffin—have triggered the explosion of intense interest in harnessing the energy of the atom to an aerial vehicle.

(1) The U. S. Air Force and Lockheed-Georgia announced that an immediate start would be made on a giant nuclear aircraft testing and research facility near Dawsonville, Ga. Reactors and laboratories of the multimillion dollar installation will be located on a 16-square-mile tract in the foothills of the Blue Ridge Mountains. Some 500 scientists, engineers, and technicians will operate the facility.

(2) Gov. Griffin of Georgia followed with the disclosure of a $300,000 appropriation to the Georgia Institute of Technology in Atlanta for a program of education and research in nuclear science and said he would ask the next session of the General Assembly of Georgia for funds, estimated at approximately $3 million, for a nuclear reactor for use by Georgia Tech.

(3) R. E. Gross, president and board chairman of Lockheed, further filled in the A-plane picture by saying that "plans are to spend many millions of dollars on facilities and equipment to adapt the Georgia operations for atomic aircraft work." Air Force financing for all the new facilities and equipment is not the policy of the company.

In addition, Lockheed has announced its major nuclear aircraft preliminary design study work will be moved to Georgia during the summer of this year. The work currently is being carried on in California as a joint effort of the company's California and Georgia Divisions.

These developments all tied together to indicate that in the next several years—and perhaps sooner—potential investment in nuclear projects in Georgia could top $100 million and employ hundreds of engineers, scientists, technical, and service people, as well as eventually a large segment of the State's industrial workers.

This atomic future in the air has burst into sight for the State with very little preliminary warning. Acceptance of the State's apparent major role in producing a nuclear-propelled airplane—perhaps the first in the world—has been instantaneous and enthusiastic.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

A-C Machine Speed

To the Editor:

The equation for the synchronous speed N of the revolving field of an a-c machine is nearly always given in terms of the number of poles P and the frequency f. In the development of the relation among these parameters, we often begin to defining the frequency as the pairs of poles passed (by an armature conductor) per second. Dimensionally, this relation is written

$$\text{frequency} = \frac{\text{pairs of poles}}{\text{revolution}} \times \frac{\text{revolutions}}{\text{second}}$$

or

$$f = \frac{P}{2} \times N \qquad (1)$$

If, however, one considers the revolving field as a traveling electromagnetic wave, equation 1 can be derived from the fundamental relationship for harmonic wave motion, namely

$$\text{velocity} = \text{frequency} \times \text{wavelength}$$

or

$$v = f\lambda \qquad (2)$$

in which

v is the phase velocity of the wave,
f the frequency, and
λ the wavelength

Now, in terms of the constants of the machine, the quantities in equation 2 can be expressed as follows, $v = \omega r = 2\pi N r$, and λ (twice the pole pitch) $= 4\pi r/P$; whence, substituting into equation 2 we have

$$2\pi N r = f \times \frac{4\pi r}{P}$$

or

$$f = \frac{P}{2} \times N$$

Equation 2 is general in that it applies to any geometry of the electromagnetic field. It also applies to the propagation of sound waves, and is perhaps first introduced in our physics courses (for example, University Physics (book), F. W. Sears and M. W. Zemansky, Addison-Wesley Press, Cambridge, Mass., 1949, p. 341) in the study of this type of wave motion.

M. M. CHRISTENSEN
(University of Utah, Electrical Engineering Dept.)

Solution of an Integral

To the Editor:

In the April 1956 issue of *Electrical Engineering* B. L. Barquist sought a solution to the following integral:

$$I(\mu) = \int_0^{\pi/2} \frac{J_0(\mu \sin\phi)\cos^2\left(\frac{\pi}{2}\cos\phi\right)}{\sin\phi}\, d\phi.$$

On April 9th I sent him essentially the following formula:

$$I(\mu) = \frac{1}{4}C(\sqrt{\pi^2+\mu^2}-\pi) + \frac{1}{4}C(\sqrt{\pi\mu^2+\pi^2}+\pi) - \frac{1}{2}\,C(\mu),$$

where

$$C(s) = \int_0^s \frac{1-\cos x}{x}\, dx,$$

and is tabulated, for example in Tables of Generalized Sine- and Cosine-Integral Functions, Harvard University Press, 1949. I believe that my formula is easier to use than the one published on page 673 of the July issue of *Electrical Engineering*. I do not suggest that you publish a derivation of my formula but I shall be glad to make it available if anyone is interested.

HARRY SOHON

(Moore School of Electrical Engineering, University of Pennsylvania)

The Favorite

To the Editor:

The very interesting article, "The Favorite," by C. T. Chave, in the May 1956 issue, certainly poses food for thought—and discussion. It seems to me the solution centers around whose money is being spent and how far the person spending the money is authorized to go so far as selecting a "Favorite" supplier is concerned.

In the case of an engineer doing work for the Government, he knows the rules as regards public bidding. In this case, all the engineer can do is write a very tight specification and then follow through to see to it that the Government gets what has been specified. If the Government eventually buys something substantially below the quality specified, then either the specification was too loose, or the engineer approving the items to be furnished was not of the same thinking as the man responsible for the original specifications.

In the case of an engineer doing work for a private organization, then at the time the work is contracted for he can discuss the procurement arrangement with his client. In some cases, he may find his client has a "favorite" supplier. This, in some instances, is due to a reciprocal business relationship. In cases where, as a result of long experience, the engineering firm has learned to rely on the quality and service of a favorite supplier and feels that prices from this supplier are in line with competitive equipment of equal quality—then, it seems to me, this situation should be carefully explained to the engineer's client.

Human nature being what it is, the experience of many buyers when purchasing equipment from a favorite, on a no-bid basis, has not been a happy one. The tendency of the seller, if he believes he has no competition, is generally to ask the higher price. When the seller *knows* he is pricing his product in a competitive market, *knows* he must meet competitive prices to get the business, he sharpens his pencil, because he knows from experience he must keep his price competitive to receive the order.

Take a situation most of us face in buying a new car every few years. Do we go to *one* dealer and accept his first offer? I don't think so. We go to at least two or three dealers who handle the make of car we wish to purchase, and ask for the best price. It is not uncommon to find a difference of as much as $500 on a used car allowance when contemplating the purchase of any of the well-known brands of automobiles.

In this case, if we have a "favorite" dealer, we may indicate to him what kind of offer he will have to make if he expects to get our business. If the "favorite" dealer refuses to meet competition, then we have the alternative of paying him the higher price or taking our business elsewhere.

As president of my company, my responsibility is to my board of directors and to the stockholders. In truth, I am held responsible for the management of other people's money. Therefore, the rule in our company is that when a capital expenditure is to be made, whenever possible, specifications are clearly defined and bids are requested. The lowest bidder who meets the specifications is found to be responsible, and has the integrity to carry through on his work in supplying equipment as specified, will receive the order.

Making our major purchases on this policy basis I feel perfectly justified in discussing any purchases with members of our board of directors. Our board of directors can, at any time, review our major purchases by examining specifications and bids received, and orders eventually placed.

Very truly yours,

DAN E. DUNNE
President

(Penn-Union Electric Corporation)

Street Illumination

To the Editor:

In the June 1956 issue of *Electrical Engineering* on page 588, appears an article entitled "Most Intensely Lighted Street Illuminated by Fluorescent Luminaires." This erroneous and misleading statement is later limited in the text as applying to New York City only. My friend Mr. Al. Larch of the City of New York has achieved a very interesting and spectacular installation which undoubtedly will stimulate business on 14th Street, with its initial illumination of 2.0 foot-candles.

In order to keep the record straight as far as the headline is concerned, it might be well to mention a few of the installations in other cities where the lighting is in excess of that called for by the ASA "American Standard Practice for Street and Highway Lighting," and equal to or above the light level on 14th Street.

Chicago, Ill., has a number of installations including portions of Michigan Boulevard, the Outer Drive, and Randolph Street, which are above this level and which are lighted with 400 watt mercury luminaires. State Street, Chicago, in the area of the Loop is lighted to a maintained value of 4.0 foot-candles with the use of 2,000 watt incandescent lamps.

Kankakee, Ill., has its main business street lighted to 5.0 foot-candles initial with 400 watt mercury lamps.

Philadelphia, Pa., has a new installation of 700 watt mercury luminaires which fall in this class.

Indianapolis, Ind., last November installed fluorescent lighting on Washington Street, using 64,000 lumen fixtures with a calculated initial level of 4.2 foot-candles.

Several large cities in Texas each have some recent noteworthy installations principally with mercury lighting.

So before we bestow the title of the "Most Intensely Lighted" let us look around the country a bit.

F. D. WYATT

(Fellow, Illuminating Engineering Society)

EDITOR'S NOTE: The article mentioned was the latest news item available for publication on this subject. It did not intend to "bestow the title," and did modify the statement with the fact that fluorescent luminaires gave the brightness.

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

ELECTRIC UTILITY RATE ECONOMICS. By R. E. Caywood. McGraw-Hill Book Company, 330 West 42 St., New York 36, N. Y., 256 pages, bound. $10. This book makes available a thorough, practical guide to many economic and technical factors involved in electric utility rate making. It provides a treatment of the subject that will help both readers directly concerned with rate work and utility people generally, who wish a basic understanding of the elements of utility rate structure development. Fundamentals of the electric utility business are described, as a foundation for discussions of such topics as the theoretical basis of the price structure and the tariff, engineering economics and cost analysis, the rate department, earnings, utility plant, depreciation, and rate of return. It points out many factors involved in rate making and indicates their relationships. Detailed methods and approaches, plus the extensive use of charges, diagrams, tables, and check lists, make it a day-to-day source of rate making information. 450 charts and diagrams illustrate the publication.

PROCEEDINGS OF THE NINTH ANNUAL CONFERENCE ON THE ADMINISTRATION OF RESEARCH. Northwestern University Technological Institute, Evanston, Ill. New York University Press, Washington Square, New York 3, N. Y., 1956. 107 pages, 8½ by 11 inches, paper. $4. These proceedings contain nine papers dealing with the research relationships between Government and industry and Government and the university. Viewpoints of university and industry executives are given, and methods for improving relationships are discussed. One of the papers is a summary of statistical data on Government-sponsored research. A panel discussion on the future of research is also included.

RADIO ELECTRONICS. By Samuel Seely. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York 36, N. Y., 1956. 487 pages, 6 by 9¼ inches, bound. $7. This text and its companion volume "Electronic Engineering" represent a revision and extension of the author's "Electron-Tube Circuits." The present volume includes a general discussion of communication-systems engineering and detailed analyses of the elements of radio systems—tuned and untuned potential and power amplifiers, oscillators, rectifiers, filters, etc. Separate chapters are devoted to amplitude modulation, demodulation, frequency modulation, and information theory. Whenever possible, both physical explanations and fairly rigorous mathematical analyses are used in the discussion.

SPHEROIDAL WAVE FUNCTIONS. By J. A. Stratton, P. M. Morse, and others, 1956. Published jointly by The Technology Press of Massachusetts Institute of Technology and John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1956. 613 pages, 8½ by 11¼ inches, bound. $12.50. The tables included in this volume are intended to make it possible for the electrical engineer or physicist to handle wave problems in spheroidal co-ordinates with approximately the same facility as has been possible previously for rectangular, circular cylinder, and spherical co-ordinates. The extensive tabular section itself is preceded by a practical introduction and a reprinted 50-page discussion of the characteristics and operational handling of elliptic and spheroidal wave functions.

ÜBERSPANNUNGEN IN ENERGIEVERSORGUNGSNETZEN. By Herbert Baatz. Springer-Verlag, Berlin, Germany, 1956. 295 pages, 6½ by 9¼ inches, bound. DM 34.50. A text on surges in high-voltage power systems that emphasizes lightning and over-voltage protection of overhead lines and distribution systems. Intended for power network engineers and students, the

practical aspects are based on a thorough theoretical treatment. An extensive, classified bibliography is included.

ASTM STANDARDS ON LIGHT METALS AND ALLOYS. Published by The American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 1955. 277 pages, 5½ by 8½ inches, paper. $3.50. These standards include specifications for wrought products for electrical purposes (bus bars, steel core wire for aluminum conductors, hard-drawn aluminum wire, etc.), as well as for ingots, castings, bars, forgings, pipe and tube, sheet and plate, and products. General methods of test and the ASTM codification system for these materials are also included.

ACCIDENT PREVENTION MANUAL FOR INDUSTRIAL OPERATIONS. National Safety Council, 425 N. Michigan Avenue, Chicago 11, Ill., third edition, 1955. Various paging, 5¾ by 9 inches, bound. $13.50. A comprehensive compilation of practical information on industrial safety principles and techniques, prepared by engineers of the National Safety Council and experts from industry. The manual is divided into 43 sections covering both general principles and practices of interest to all industry—education, organizing a program, records, etc.—and techniques essential to the safe operation and maintenance of different types of equipment: boilers, pressure vessels, conveyors, machine tools, elevators, power trucks, etc. Many local and federal government standards and those of code-making associations are cited in the text.

APPLIED AUTOMATION. A group of significant articles from the pages of *Automotive Industries*. Edited by J. R. Custer. Chilton Company, Chestnut and 56th Streets, Philadelphia 39, Pa., 1956. 236 pages, 8½ by 11¼ inches, bound. $6. These articles cover automation in machining, stamping, welding, forging, heat treating, plating, painting, inspection, testing, assembling, and other operations in the automobile and aircraft industries. The book is indexed by broad subjects.

AUTOMATIC DATA PROCESSING. Proceedings of the Conference, September 1955. Edited by R. N. Anthony. Graduate School of Business Administration, Harvard University, Boston, Mass., 1956. 194 pages, 5½ by 8½ inches, paper. $3.50. This conference was held in order to acquaint engineers with the requirements of businessmen for data processing and to acquaint businessmen with the potential uses and limitations of new equipment. The conference consisted of five sessions at which papers covering the following subjects were presented: basic principles and techniques; centralization vs. decentralization of data processing in large companies; recent developments in equipment; applications to ordering, production planning, and payroll; and the relationship of operations research to automatic data processing.

CLOSED-CIRCUIT AND INDUSTRIAL TELEVISION. By E. M. Noll. The MacMillan Company, 60 Fifth Avenue, New York 11, N. Y., 1956. 230 pages, 6 by 9 inches, paper. $4.95. The first chapter includes brief descriptions of a number of uses of closed-circuit television as a monitoring device in steel mills, power plants, railroad yards, and other locations, and as a means of communication in schools, hospitals, business, etc. Seven chapters deal with the technical aspects of systems, cameras, viewers, circuits, installation, and servicing, and the last chapter presents construction details for a small inexpensive camera.

COMPUTERS; THEIR OPERATION AND APPLICATIONS. By E. C. Berkeley and Lawrence Wainwright. Reinhold Publishing Company, 430 Park Avenue, New York 22, N. Y., 1956. 366 pages, 6 by 9 inches, bound. $8. Basic information is presented on the elements, reliability, maintenance, advantages, and limitations of analogue and digital computers, including large-scale and miniature types. A fairly extensive section on applications gives brief notes on a wide range of actual and potential, business, military, and other uses of computers. Also included are a list of computers now in operation, a roster of organizations offering consulting and other services, a glossary, and a selected bibliography.

ELECTRONICS AND ELECTRON DEVICES. By A. L. Albert. The MacMillan Company 60 Fifth Avenue, New York 11, N. Y., 1956. 582 pages, 6⅛ by 9⅛ inches, bound. $8. This text for a basic course in the subject is a revision of the author's "Fundamentals of Electronics and Vacuum Tubes," covering, in general, electronic principles, their applications to electron devices, and the use of these devices in electric circuits. In revising the book, the author has incorporated a discussion of semiconductor theory in the chapter on basic theory and has added new chapters on semiconductor devices, semiconductor circuits, magnetic amplifiers, and wave-shaping and control circuits.

ELECTRONICS IN INDUSTRY. By G. M. Chute, McGraw-Hill Book Company, 330 West 42nd Street, New York 36, N. Y., second edition, 1956. 431 pages, 6 by 9¼ inches, bound. $7.50. A broad introduction to the use of electronic circuits and equipment, intended for users of available equipment and as a textbook. Early chapters deal with the fundamentals of tubes and circuits; later chapters with a wide range of equipment including welding controls, light and heat relays, speed and voltage regulators, and temperature recorders. In this revision, recent designs of industrial controls have been substituted for outmoded designs, and a chapter on simple closed-loop systems has been added.

ELEMENTARY NUCLEAR THEORY. By H. A. Bethe and Philip Morrison. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., second edition, 1956. 274 pages 5½ by 9¼ inches, bound. $6.25. This is an introduction to the subject for students and scientists who are not specialists in nuclear physics. As in the first edition, the central theme is the problem of nuclear forces treated from the empirical point of view. In their revision, more space has been devoted to the structure and reactions of heavier nuclei. In addition, the book has been expanded to twice the number of pages in order to take into account theoretical and experimental advances, particularly in the energy range of hundreds of Mev. The appended table of nuclear species and their masses has also been revised.

50 JAHRE GRENZSCHICHTFORSCHUNG. Eine Festschrift zu Ehren von Ludwig Prandtl. Edited by H. Görtler and W. Tollmien. Friedrich Vieweg und Sohn Verlag, Braunschweig, Germany, 1955. 499 pages, 6⅝ by 9⅝ inches, bound. DM 66. A compilation of 44 original contributions in boundary layer research comprising a memorial volume to Ludwig Prandtl. A wide range of subject matter is included: mathematical analyses of various aspects; boundary layer phenomena in liquids, gases, and electron streams; heat transfer and turbulence effects; experimental methods, measurements, and computations; similitude investigations; and several specialized items, such as the use of the sailplane in boundary layer research. Over half of the papers are in English, the rest mainly in German.

THE GROWING SHORTAGE OF SCIENTISTS AND ENGINEERS. Proceedings of the Sixth Thomas Alva Edison Foundation Institute, November 1955. New York University Press, Washington Square, New York 3, N. Y., 1956. 132 pages, 8½ by 11 inches, paper. $4. The speeches and panel discussions recorded in these proceedings deal with the present and future supply and demand for scientists and engineers, the efficient utilization of scientific manpower, means for increasing the supply of engineers, the encouragement of scientific talent, the failures of scientific education, and methods for improving science teaching.

INDUSTRIAL ORGANIZATION AND MANAGEMENT. By L. L. Bethel and others. Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., third edition, 1956. McGraw-Hill 719 pages, 6 by 9¼ inches, bound. $6.75. A text and reference book presenting a broad picture of the functions of an industrial enterprise: plant engineering, research engineering, quality control, production control, industrial relations, accounting, etc. This edition takes into account developments in automation, operations research, and applications of electronics to plant and office operations, as well as new policies and practices in a number of fields.

MESSEN UND RECHNEN IN DER PHYSIK. By Ulrich Stille. Friedrich Vieweg und Sohn, Braunschweig, Germany, 1955. 416 pages, 7½ by 11 inches, bound. DM 54. A study of the entire subject of measuring and calculating in the basic fields of physics. It covers the development of modern physical concepts, laws, quantities, and units under various sections: fundamentals and definitions; mechanics; heat and radiation; electricity and magnetism; acoustics and optics; values of constants. Extensive tables of constants, conversion factors, etc., a bibliography of 984 items, and a detailed subject index are included in this thorough treatment of a fundamental subject.

MODERN NETWORK SYNTHESIS. Proceedings of the Symposium, April 1955. Published by Microwave Research Institute, Polytechnic Institute of Brooklyn, Brooklyn, N. Y., 1956. 528 pages, 5½ by 9 inches, bound. $5. The first three papers in these proceedings are reviews of recent advances in the synthesis of passive and reciprocal, nonreciprocal, and active networks; the remaining 21 papers deal with specific topics in the fields of time domain synthesis and network design. Some of the topics dealt with are time domain filter operations, synthesis of four-wire conference networks, synthesis of active filters, and design theorems for wide-band transistor amplifiers. Lists of references accompany most of the papers.

MOLECULAR FLOW OF GASES. By G. N. Patterson. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1956. 217 pages, 5⅞ by 9¼ inches, bound. $7.50. In this book for engineers and physicists, the characteristics of the isentropic and non-isentropic flow of a monatomic gas are determined from an assumed molecular model and the distribution of the velocities of the molecules. One chapter is devoted to the mechanics of rarefied gases, and some discussion of strong shock waves is included in which effects arising from complex molecules are considered. Material from both the kinetic theory of gases and fluid mechanics is used to develop and illustrate the molecular approach.

OPERATIONS RESEARCH FOR MANAGEMENT. Volume II. Edited by J. F. McCloskey and J. M. Coppinger. The Johns Hopkins Press, Homewood, Baltimore 18, Md., 1956. 563 pages, 6 by 9¼ inches, bound. $8. The first part of this book consists of 13 reports on the application of operations research to such problems as traffic delays at toll booths, ore-handling at British ports, the influence of vehicle speed and spacing on tunnel capacity, analysis of a railroad classification yard, and inventory control. The design of experiments, analyzing failures, operational gaming, and other methods are discussed in the second part. The last part deals with problems of group communication and organization.

RANDOM PROCESSES IN AUTOMATIC CONTROL. By J. H. Laning, Jr., and R. H. Battin. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, 36, N. Y., 1956. 434 pages, 6 by 9¼ inches, bound. $10. The first part of this book deals with the fundamental concepts of probability theory and of the statistical properties of random functions of time. These basic concepts are then applied to the study of the shot effect and Gaussian random functions. Later chapters treat stationary random processes as inputs to time-invariant linear systems; mean-squared error analysis in time-variable linear systems; optimum systems synthesis; and optimum operations with finite data. Supplementary material, including a discussion of the theory of the operation of analogue computers, is given in appendixes.

REACTOR SHIELDING DESIGN MANUAL. Edited by Theodore Rockwell, III. D. Van Nostrand Company, Inc., 120 Alexander Street, Princeton, N. J. first edition, 1956. 472 pages, 8 by 10¾ inches, bound. $6. A detailed presentation of procedures and data used in the design, construction, and testing of shielding for the reactor plants of the Naval Reactors Program and for the Shippingport Pressurized Water Reactor. Intended as a practical guide for designers of stationary as well as mobile reactors, the manual covers basic theory, setting allowable radiation levels, core and cooling system shields, plant layout as a factor in design, materials, provision for access for repair and maintenance, the effect of irregularities in shields, and the effect of the geometry of radiation. Basic data and calculation aids are provided in the last chapter.

REPORT OF THE CONFERENCE ON RELIABILITY OF ELECTRICAL CONNECTIONS, APRIL 1954. Illinois Institute of Technology, Chicago, Ill. Published by Radio-Electronics-Television Manufacturers Association, 500 Fifth Avenue, New York 36, N. Y., 1955. 76 pages, 8½ by 11 inches, paper. $5. The 15 short papers in this report deal with methods and techniques of connecting wires, terminals, and circuit elements, and methods and techniques for the control of quality in connections. Both soldered and solderless connections are discussed.

SEMINAR ON AUTOMATION, PROCEEDINGS. Pennsylvania State University, June 1955. Edited by Chester Linsky. Available from Extension Conference Center, The Pennsylvania State University, University Park, Pa. Various paging, 8½ by 10½ inches, paper. $5. These proceedings include the papers, workshop discussions, and question and answer sessions which made up a seminar held for product designers and manufacturing engineers interested in learning the tools

and techniques associated with the organization, planning, design, and operation of automated systems. The 20 papers and one panel discussion included deal with machine tool automation, hydraulics in automation, process controls, automatic assembly machines, digital control, economic considerations, labor problems, and related topics. A number of full-page photographic reproductions are used to illustrate the papers.

SOLID STATE PHYSICS. Volume II. Edited by Frederick Seitz and David Turnbull. Academic Press, Inc., Publishers, 125 E. 23rd Street, New York 10, N. Y., 1956. 468 pages, 6 by 9¼ inches, bound. $10. The second volume in a projected series of about a dozen volumes intended to provide concise and authoritative reviews of important areas of the field. The present volume consists of five papers on the following subjects: nuclear magnetic resonance, electron paramagnetism and nuclear magnetic resonance in metals, applications of neutron diffraction to solid state problems, the theory of specific heats and lattice vibrations, and displacement of atoms during irradiation. Bibliographical footnotes accompany each paper, and a subject index and index of authors cited are included.

TRANSISTORS I. A Selection of Papers. RCA Laboratories, Radio Corporation of American, Princeton, N. J., 1956. 676 pages, 5⅞ by 8½ inches, paper. $4.50. The 41 papers making up this book are grouped into six sections: general, materials and techniques, devices, fluctuation noise, test and measurement equipment, and applications. The subjects covered include basic concepts, advances in the junction transistor, semiconductor diodes, thermal conversion in germanium, audio amplifiers, components for television receivers, and transistorized electronic counters. All but 10 of the papers have not been published previously.

TRANSISTORS HANDBOOK. By W. D. Bevitt. Prentice-Hall, Inc., Englewood Cliffs, N. J., 1956. 410 pages, 5½ by 8½ inches, bound. $9. The first half of this practical manual for engineers, technicians, and students covers fundamental concepts, measurements, noise and temperature effects, methods of analysis, and characteristics of the different types of transistors—point-contact, junction, power, tetrode, pentode, photodiodes, and phototransistors. The last half of the book deals with specific circuits and practical applications, including audio and radio frequency amplifiers and oscillators, power amplifiers, amplitude and frequency modulation, radio and television receivers, relaxation oscillators, and computer circuits.

SYMPOSIUM ON MONTE CARLO METHODS, MARCH 16 AND 17, 1954. Conducted by Statistical Laboratory, University of Florida. Sponsored by Wright Air Development Center of Air Research and Development Command. Herbert A. Meyer, editor. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1956. 382 pages, 8½ by 11¼ inches, bound. $7.50. This publication contains an introductory paper reviewing the progress in field from 1949 to 1954, and 19 papers devoted to the theory and applications of the method and to the generation of random numbers. Appended bibliographies list papers (some with abstracts) on random digits, empirical sampling, and stochastic processes, as well as papers directly concerned with the method.

VIERPOLTHEORIE UND FREQUENZTRANSFORMATION. By Tobern Laurent. Springer-Verlag, Berlin, Germany, 1956. 299 pages, 6½ by 9¼ inches, bound, DM 34.50. A textbook on four-pole theory and frequency transformation, essentially concerned with the mathematical aspects of systematic analysis and theoretical investigation of electrical transmission circuits (telephone and telegraph). A great many network arrangements and connections are presented as illustrative examples. There is a bibliography.

BASIC ENGINEERING SCIENCES, SOLUTION TO PROBLEMS. By William Glendinning. Available through author, 5123 Bell Boulevard, Bayside, N. Y., fourth edition, 1956. 122 pages 8½ by 10⅞ inches, paper. $3. Detailed solutions to selected problems from Part II of the N. Y. State professional engineering examinations given over the past 10 years through February 1956. The fields covered include mechanics, machine design, hydraulics, thermodynamics, and electricity. Illustrative diagrams have been used wherever they are necessary.

CAREERS IN ENGINEERING. By L. O. Stewart. The Iowa State College Press, Press Building, Ames, Iowa, third edition, 1956. 105 pages, 6 by 9 inches, paper. $1.25. This booklet gives information on the nature of the engineering profession; the aptitudes, interests, and personality necessary for the study of engineering; factors that determine success in college and after; and the engineer's fields of work. The engineering fields are considered from three points of view: by degree-granting departments of universities, by industries employing engineers, and by function such as design, construction, research, etc. Aids to counselors and teachers and other books on the profession are listed in an appendix.

GRUNDZÜGE DER TENSORRECHNUNG IN ANALYTISCHER DARSTELLUNG. Part III, Anwendungen in Physik und Technik. By Adalbert Duschek and August Hochrainer. Springer-Verlag, Vienna, Austria, 1955. 250 pages 5⅜ by 8½ inches, paper. $5.70. This third volume of a standard German text on tensor analysis discusses, with considerable illustrative detail, applications in the fields of physics and engineering, particularly in mechanics, hydrodynamics, heat, and electromagnetism.

KRISTALLODEN TECHNIK. By R. Rost and H. M. Ernst. W. Ernst and Sohn, Berlin, Germany, second edition, 1956. 439 pages, 5⅜ by 8⅜ inches, bound. DM 26. A concise but comprehensive summary of the published information on transistor technology, through 1955. The first three sections cover, respectively, atomic phenomena involved in rectification and amplification, manufacture and testing of crystal diodes and transistors, and applications. The fourth section gives technical data on the products of German and other European manufacturers. The chronological bibliography appears at the back of the volume.

MISE EN ÉQUATIONS ET RÉSOLUTION DES RÉSEAUX ÉLECTRIQUES EN RÉGIME TRANSITOIRE PAR LA MÉTHODE TENSORIELLE. By A. Kaufmann. Publications Scientifiques et Techniques, No. N. T. 56, Ministere de L'Air, Paris, France, 1955. 104 pages, 7¼ by 10½ inches, paper. F.fr. 1100. An extension of Kron's classic studies on the tensor analysis of networks, which seeks to establish somewhat more rigorous solutions, and also to demonstrate the use of tensor analysis for asymmetrical networks and for transient conditions.

MOLECULAR BEAMS. By N. F. Ramsey. Oxford University Press, 114 Fifth Avenue, New York 11, N. Y., 1956. 466 pages, 6 by 9¼ inches, bound. $12. This is a detailed treatment of molecular beam experiments and of the applications of molecular beam techniques. It includes discussion of applications in the study of gas kinetics; the measurement of atomic and nuclear spins and magnetic moments by the magnetic resonance method; the radio frequency spectra of atoms; measurements of nuclear electric quadrupole moments; and the measurement of the structure of atomic hydrogen. Two chapters are devoted to the design of experiments and experimental techniques.

NEUTRAL GROUNDING IN HIGH-VOLTAGE TRANSMISSION. By R. Willheim and M. Waters. Published by Elsevier Publishing Company, 1956. Available in the United States from D. Van Nostrand Company, Inc., 120 Alexander Street, Princeton, N. J. 669 pages 6¼ by 9¼ inches, bound. $15. A comprehensive discussion of the various European and American methods of neutral grounding and other measures for reducing the fault rate in transmission systems. The first third of the book, devoted to ground faults and grounding practice, deals with the theory of neutral grounding, transient phenomena in three phase systems, and methods of fault suppression. The rest of the book is a detailed treatment of resonant grounding, covering the theory, design, applications, and testing of the ground fault neutralizer (arc suppression coil). A great many numerical examples and actual tests and measurements are included, and each chapter is followed by a list of references and a bibliography.

PHYSICS AND CHEMISTRY OF THE EARTH. Volume 1. Edited by L. H. Ahrens, K. Rankama, and S. H. Runcorn. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1956. 317 Pages, 5⅞ by 9¼ inches, bound. $8. This first volume of a new series of surveys of advances in the fields of geochemistry and geophysics contains critical reviews of the following topics: the origin of the solar system; temperatures within the earth, radioactive methods for determining geological age, seismology and the earth's interior structure, hydrodynamics of the earth's core, investigations under hydrothermal conditions, the geochemistry of the halogens, and geochemistry in the U.S.S.R. A list of references accompanies each review.

PRINCIPLES AND TECHNIQUES OF APPLIED MATHEMATICS. By Bernard Friedman. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N.Y., 1956. 315 pages, 5⅞ by 9¼ inches, bound. $8. An analysis of the methods developed in theoretical studies which can be used to systematize the solution of problems likely to be met by applied mathematicians, physicists, and engineers. In addition to providing a thorough grounding in linear spaces, special theory of operators, Green's functions, eigenvalue problems, and partial differential equations, the book demonstrates that logical analysis of a problem leads to the proper method for its solution.

PRINCIPLES OF COLOR TELEVISION. By The Haseltine Laboratories Staff, and K. McIlwain and C. E. Dean, editors. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1956. 595 pages, 5⅞ by 9¼ inches, bound. $13. Intended for engineers already familiar with the theory and techniques of monochrome television, this book covers principles of colorimetry, general principles of the reproduction and transmission of color pictures, and transmitting, receiving, measuring, and test equipment. A study of Federal Communications Commission color standards and a glossary are included, and references are listed after each chapter.

PRINCIPLES OF ELECTRIC AND MAGNETIC FIELDS. By W. B. Boast. Harper and Brothers, 49 East 33rd Street, New York 16, N. Y., second edition, 1956. 418 pages, 6 by 9¼ inches, bound. $6. The first two parts of this introductory text deal with basic concepts, the last part with such supplementary aspects of the subject as permanent magnets, transient response, measurements of electric charge, and estimating capacitance. A new chapter providing an introduction to Maxwell's field equations has been added in the new edition, and several changes have been made in the arrangement of material.

RADIO AND ELECTRONIC COMPONENTS. Volume 2, Variable Resistors and Potentiometers. By G. W. A. Dummer. Sir Isaac Pitman and Sons, Ltd., London, England, 1956. 176 pages 5½ by 8¼ inches, bound. 30s. The second in a series of books on the characteristics and uses of components based on types used by the British armed services. The present volume covers measurements on variable resistors, wire characteristics, curve matching with variable resistors, general purpose and precision resistors, and special and experimental resistors and potentiometers. Comparison charts of representative types and a bibliography of over 100 references are included.

RESISTANCE WELDING, THEORY AND USE. By Resistance Welding Committee, American Welding Society. Reinhold Publishing Corporation, 430 Park Avenue, New York 22, N. Y., 1956. 163 pages, 6 by 9¼ inches bound. $4.50. A review of fundamental principles and techniques, intended as a manual for experienced engineers and designers as well as an introduction to the subject for those unfamiliar with the method. The book treats spot, seam, projection, flash, upset, and percusion welding; describes the different types of welding machines, electrodes, and controls used; and discusses weldability, quality control, and testing.

SCIENCE AND INFORMATION THEORY. By Leon Brillouin. Academic Press, Inc., 125 East 23rd Street, New York, 10, N. Y., 1956. 320 pages, 6 by 9¼ inches, bound. $6.80. A mathematical treatment of the modern theory of communication, based on lectures delivered to practicing engineers and graduate students. In the opening chapters, a definition of information is derived from statistical considerations, and such basic problems as redundancy in language, coding, and error detection are considered. Other subjects discussed include Maxwell's demon, the connection between information and entropy, and the Nyquist noise formula. Applications of information theory in telecommunications, computing, pure physics, and the fundamental processes of scientific observation are dealt with in the last chapters.

SOLUTIONS TO ELECTRICAL ENGINEERING PROBLEMS. By William Glendinning. Available through author, 5123 Bell Boulevard, Bayside, N. Y., third edition, 1956. 108 pages, 8½ by 11 inches, paper. $3. Solutions to problems in all major phases of electrical engineering, with illustrations and vector diagrams where necessary for clarity. The problems have been selected from Part III of the N. Y. State professional engineering examinations given over the past 10 or more years through February 1956.

PAMPHLETS

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

FIRE AND ACCIDENT LOSS CONTROL INDEX AND DIRECTORY. An entirely new professional "Information Service" is now available for use in the fire and accident control fields. The service covers the many problems connected with preventing or limiting loss from both fire and accident. It is the only one of its kind in these fields. The service includes an Index and Directory and a Supplemental Service which will be issued at six-month intervals to keep the Index and Directory strictly up to date. It will enable the user to locate quickly and easily virtually any information and data he may desire on the many phases of accident prevention and fire control. The Index and Directory consists of three separate parts. First, there is an extensive Index of subjects pertaining to fire and accident control under each of which is listed the many publications in which information concerning the particular subject may be found. Second, it includes a Guide that calls to the user's mind the various considerations and preventive actions necessary on each subject. Third, and finally, it includes a Directory listing all of the thousands of publications referenced in the Index and Guide section, showing their availability, procurement source, and price. The Index and Directory consisting of approximately 1,200 pages, includes over 10,000 subjects and 50,000 references. It is also extensively cross referenced. The cost of the Index and Directory is $48.50 and the Supplemental Service $17.50 per year. The publishers are Loss Control Associates, 629 Oakmont Drive, Plattsmouth Neb.

KEEPING PACE WITH AUTOMATION—PRACTICAL GUIDES FOR THE COMPANY EXECUTIVE. From general considerations to the specifics of company experience, this American Management Association Special Report Number 7 surveys many aspects of current automatic processing and looks at the possible effects of automation on future processes, managers, and workers. On the basis of the experience of companies that have already successfully automated manufacturing processes, the report suggests answers to questions like: Will centralized control be possible? How automatic can we get? What is the impact of automation on the average worker? It also includes a section on basic theory, which gives executives a good background in automation techniques and methods, automatic controls for the job shop, and similar subjects. Copies may be obtained from the American Management Association, 1515 Broadway, New York 36, N. Y. 136 pages, $3.75 (AMA members: $2.50.)

TECHNIQUES OF PLANT MAINTENANCE AND ENGINEERING—1956. This comprehensive report on modern practices in plant maintenance and engineering contains the proceedings of the conference held with the Plant Maintenance and Engineering Show. Included are the texts of 16 papers, summaries of 15 roundtable discussions, and answers to approximately 1,100 specific questions. This year's book, seventh in the series, is the broadest in scope. Five industries get special attention: air transport shops, chemical plants, petroleum refineries, paper mills and paper product plants, and textile mills. Subjects include preventive maintenance, getting maintenance people to work as a team, measuring the effectiveness of maintenance, sanitation, equipment replacement policies, independent contractors, 24-hour operation, painting, design and operation of maintenance shops, cost control, inspection procedures, building and yard structure maintenance, use of punched cards, electrical equipment, lubrication, machine tools, report writing, relationship between maintenance and purchasing departments, utilities, forms and reports, and tool room control. 248-page (with 110 illustrations, charts and tables) book may be obtained from Clapp and Poliak, Inc., 341 Madison Ave., New York 17, N. Y., $10 postpaid.

ENERGY DISTRIBUTION IN LUMINESCENCE. Spectra of Organic Compounds. PB *111872* printed by the Univ. of Colorado for Office of Naval Research. A new system for the detection of infrared radiation (7,000 A–20,000 A) is described which uses a lead sulfide photoconductive cell and a high gain a-c amplifier. Using this new detector, infrared phosphorescence of a number of different substances was studied. Phosphorescent emission was found for a series of cadmium sulfide-zinc sulfide phosphors up to a wave-length of 9,000 A. As a result of the frequent use of solutions of fluorescent materials in scintillation counters, interest in the phenomenon of energy transfer in phosphor systems has been greatly stimulated. Ordinary spectrographic procedures were employed in this study to determine the fluorescence spectra of solutions of various organic compounds. 163 pages. $4.25. Order PB *111872* from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.

AMERICAN STANDARD HEXAGON HEAD CAP SCREWS, SLOTTED HEAD CAP SCREWS, SQUARE HEAD SET SCREWS, AND SLOTTED HEADLESS SET SCREWS. ASA *B18.6.2-1956*. This Standard combines in a single document standards for the principal types of cap and set screws, except for socket head products (published in ASA *B18.3-1954*). It represents the joint efforts of two Subcommittees of Sectional Committee B18, Subcommittee 1 having responsibility for standardization of hexagon head cap screws and square head set screws, and Subcommittee 3 having responsibility for slotted head cap screws and for slotted headless set screws. 21 pages, published by the American Society of Mechanical Engineers (ASME). Copies may be obtained from the ASME Order Department, 29 West 39th Street, New York 18, N. Y., at $1.50 per copy.

1956 NATIONAL DIRECTORY OF SAFETY FILMS. The directory provides a compact source of information on films on safety, first aid, fire prevention, and civil defense. It describes more than 1,200 films that are available without restriction on distribution. Information includes millimeter, running time, color, year of production, and a brief summary of the plot. Among the subjects covered are industrial, commercial transport, traffic, home, farm, and education. Many of the films are cleared for television and some for theatrical distribution. Each film is available for purchase, rental, loan, or long-term lease from one or more of 292 distributors. The directory includes a separate listing for those organizations which limit distribution to specific areas in the United States and Canada. These distributors usually make films available for loan or low-cost rental and are excellent sources for public safety films. A single copy of the directory may be purchased for $1 from the National Safety Council, 425 N. Michigan Ave., Chicago 11, Ill.

RESEARCH ON TREATED MAGNESIUM SURFACES. PB *121140*. Research toward development of an accelerated performance test for treated magnesium alloys is described in an Air Force report released to industry through the Office of Technical Services, U. S. Department of Commerce. Test methods for evaluating the quality of chemical and electrochemical surface treatments with respect to corrosion resistance afforded by the treatments to the base metal, and the adherence between paint type coatings and the base metal afforded by surface treatments, are needed to determine the acceptability of magnesium alloys submitted to the military services. Corrosion resistance tests included pH increase in 1.0N KCl, open circuit potential comparisons, short circuit current comparisons, and hydrogen evolution rates in 1.0N KCl (gasometric method). Tests of adhesion of zinc chromate primer to the treated surfaces included adhesion in shear (wrought alloy specimens), adhesion in tension (cast alloy specimens), and impact, ultrasonic vibratory, and pressure-sensitive type tests (qualitative). The gasometric method was the most promising for evaluation of corrosion resistance. This booklet by S. E. Rohowetz, Bjorksten Research Laboratories, Inc., for Wright Air Development Center, may be ordered from OTS, U. S. Department of Commerce, Washington 25, D. C. It contains 187 pages, price $4.75.

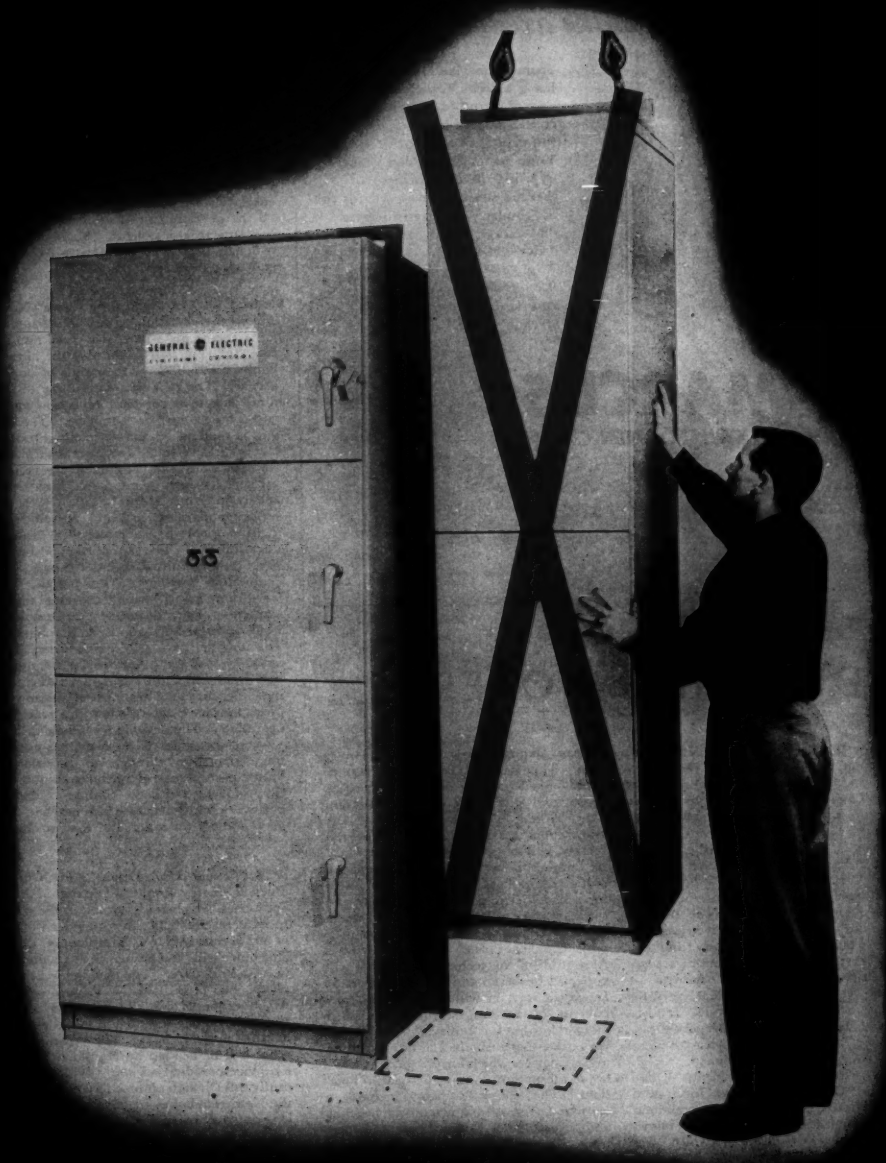
NEMA STANDARDS PUBLICATION FOR MINING AND INDUSTRIAL ELECTRIC LOCOMOTIVES: NEMA Publication No. *MI 1-1956*. The following information is given in this publication for trolley-type, storage-battery-type and combination-type mining and industrial electric locomotives: (a) general—sizes and classes of locomotives, drawbar pull, speeds, horsepower, tools, and accessories; (b) motors—rating, insulation, efficiency, and characteristic curves; (c) control—classes of control equipment, single- and double-end control, method of control, tandem control, and transfer switch; (d) construction—brakes, air compressor capacities, sand rigging, wheels, clearances, journal bearings, gears, wiring, headlights, cable reels, cabs and canopies, and axle suspension; and (e) weights of components. Available from National Electrical Manufacturers Association, 155 East 44th Street, New York 17, N. Y. $1.75 per copy.

SPECIFICATIONS FOR FARMSTEAD WIRING. A comprehensive booklet which provides requirements for methods of farm wiring installations and details types of materials to be used, has been produced by the Farm Wiring Subcommittee, Farm and Rural Market Development Committee of the National Electrical Manufacturers Association. The book presents information on several key problems of interest to utility companies, Rural Electrification Administration (REA) co-operatives, and electrical contractors. They include specifications for circuit capacity, selection of wiring materials, grounding, proper installation of branch circuits, guide to farmstead service entrance equipment, and provisions for typical and practical farm wiring installation contracts. The most complete guide for installers of farmstead wiring issued in several years, the book was developed in accordance with recommendations set forth in the National Electrical Code and the Farmstead Wiring Handbook. It is a successor to the original and now outdated Farm Wiring Specifications Book published by the REA in 1949. The book is available from the Farm Electrification Bureau, National Electrical Manufacturers Association, 155 East 44th Street, New York 17, N. Y., at the following cost prices: Single copies, 25¢; 10 to 99 copies, 15¢ each; 100 to 999 copies, 13¢ each; and 1,000 copies and over, 11¢ each.

AMPLITUDE AND PHASE CURVES FOR GROUND-WAVE PROPAGATION IN THE BAND 200 CYCLES PER SECOND TO 500 KILOCYCLES. By J. R. Wait and H. H. Howe, National Bureau of Standards Circular 574. The curves presented in this publication provide basic information on ground-wave propagation in the low, very low, and ultralow frequency bands. The propagation characteristics of very low frequency radio waves have wide interest. Only slightly affected by ionospheric disturbances for ranges up to about 200 miles, they are suitable for communication, navigational systems, and geophysical prospecting. Electromagnetic energy at frequencies as low as 100 cycles and less is also present in lightning discharges. To arrive at the curves several extensions were made to the formulas of Van der Pol and Bremmer. Ground conductivity values of 4, 0.01, and 0.001 mhos per meter were chosen, corresponding to sea water, well-conducting land, and poorly conducting land, and the field strength and phase values were computed at the selected frequencies. The distances considered range from 1 to 1,500 miles. Because of the excessively large computation required, the National Bureau of Standards Electronic Automatic Computer (SEAC) was used. 17 pages, 20¢. Order from the Government Printing Office, Washington 25, D. C. Foreign remittances must be in U. S. exchange and should include an additional one-third of the publication price to cover mailing costs.

SYSTEMS ENGINEERING. A report prepared for the U. S. Navy designed to aid the systems engineer is now available to the public from the Office of Technical Services, U. S. Department of Commerce. The author defines the systems engineer as a man who, when assigned to a project, is capable of co-ordinating and preparing or carrying out three things—first, an optimum scheme (system survey) showing the interrelation of all factors that will affect the project and sway future action; second, an optimum set of organized ideas (the plan of procedure) pertaining to carrying out the project; and third, an optimum physical realization (the product) of the devices necessary to terminate the project. To provide useful material for the systems engineer in any industry, technical considerations are eliminated and only material common to most systems problems is included in the book. An introduction to systems engineering is given, the factors surrounding a typical systems-engineering problem are enumerated, and the systems design process is outlined. The system survey, a preliminary step in the systems-engineering process, and the organized project plan are discussed, and a check list is given for each. Ideal and optimum tests are defined. Based on the development cycle, product development is examined from the systems-engineering viewpoint, and the subject of system tests is treated, with a check list given. The report concludes with a discussion of the completion and reinstigation of projects. This report, PB *111801*, by J. N. Warfield, Ordnance Research Laboratory, The Pennsylvania State University, for the Navy Bureau of Ordnance, may be ordered from OTS, U. S. Department of Commerce, Washington 25, D. C. It contains 30 pages, price 75¢.

. LEADER IN DESIGN AND PERFORMANCE



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INDUSTRIAL NOTES ....

Burndy's "Hyliner." Gov. A. A. Ribicoff, Connecticut, and executives of the State's copper and brass industry were guests of Burndy Engineering Company, Inc., at an open house and dedication ceremony at the company's main plant in Norwalk, Conn., on August 23. Governor Ribicoff christened a large transcontinental-type vehicle with the name "Hyliner," which is a mobile display unit to show products of Burndy's newly organized Omaton Division. The division was established to serve the electrical and electronic manufacturing, military, and aircraft markets. The other dignitaries present included Mayor G. R. Brunjes of Norwalk; C. W. Buhler, president, Norwalk Chamber of Commerce; A. R. Zender, executive vice-president, Bridgeport Brass Company; E. B. Tracy, vice-president (sales), American Brass Company; G. P. Bakken, executive vice-president, Chase Brass and Copper Company, Inc.; and Arthur Hickox, executive vice-president, Scovill Manufacturing Company. Following the Hyliner dedication, which was attended by the Norwalk plant's more than 700 employees and their families, Burndy's guests then were conducted on a tour of the main plant following the dedication.

Edison Acquires New Electronic Operation. Thomas A. Edison, Inc., has acquired the Roseland, N. J., plant, equipment, and inventory of Infra Electronic Corporation. The amount of the cash transaction was not disclosed. The new facility will be operated as Plant No. 2 of Edison's Instrument Division and will make and market the same precision instrument system components now being produced. Infra's Roseland factory makes servo and synchro motors and other components of airborne electronic systems. Almost all of the technical personnel who perfected the servo and synchro motors for Infra will stay on with Edison. As components of systems, servo and synchro motors interpret complex "orders" from various sensing elements and transmit these to slave devices which furnish the "muscles" needed to perform automatic control functions. The Roseland plant includes a modern one-story manufacturing building and several other buildings on a six-acre tract. There are a total of 26,000 square feet of floor space.

New Laboratory. The Nuclear Research Laboratory of the General Atomic Division of General Dynamics Corporation will be named in honor of Dynamics' founder, chairman, and president, John Jay Hopkins. Directors of the Corporation announced that the laboratory, to be built at San Diego, Calif., will be designated as the "John Jay Hopkins Laboratory for Pure and Applied Science." Actual construction of the laboratory will start soon. Completion of the initial building phase is expected in 1957. The Hopkins Laboratory will be under the direction of Dr. E. C. Creutz, formerly head of the department of physics and director of the Nuclear Research Center at Carnegie Institute of Technology. General Atomic will pursue research and development in the nuclear energy field. Among its initial goals will be the development of more efficient and economic reactor systems. Major emphasis will also be placed on materials research and basic nuclear work.

Patent for Coin Dimpling Ram. North American Aviation, Inc., has applied for a patent on a new, two-piece ram for coin dimpling that could save the aircraft industry hundreds of thousands of dollars a year. The new ram lasts three to five times as long as one-piece rams now in use and is much cheaper to replace. The savings is realized in coin dimpling, a process used in making today's supersonic airplanes whereby a die forms a rounded recess under pressure on sheet metal so that flush rivets and countersunk screws lie flush with the surface and offer no wind resistance in flight. A hole is first punched or drilled, then dimpled. The ram portion of the die supports the dimple around the hole, thus eliminating cracking of the metal. The new ram has overcome several disadvantages. The old dies have tapered sides, which lessen accuracy under continuous use. The new die has vertical shoulders. The old dies tend to collect metal fragments that eventually cause inaccuracy and cracking. Because they are tapered and in one piece, they have to be made with a precision operation. The new die has a hole drilled through the upper part, so that chips and fragments drop through to the slotted button base, instead of collecting around the sides as in the old dies. Simpler in design but every bit as accurate, the new die can be made on an automatic tool machine.

ACF Nuclear Unit Opens New Office. Nuclear Energy Products Division of ACF Industries, which is expanding in the commerical reactor field, has opened an office at 508 Kennedy N. W., Washington, D. C. The office will be a branch of the main one in New York City. The Division has three plants, two in Buffalo, N. Y., and one in Albuquerque, N. M. These employ 2,600 persons including several hundred engineers in the nuclear field. The Washington office will be headed by Harold Etherington, vice-president of the Division. Recently this Division obtained a contract from the Netherlands for the construction of an experimental reactor in that country, and has other contracts for building similar reactors for the Massachusetts Institute of Technology in Boston and Milano University in Italy.

(*Continued on page 28A*)

HUGHES PRODUCTS

presents 3 unusual new

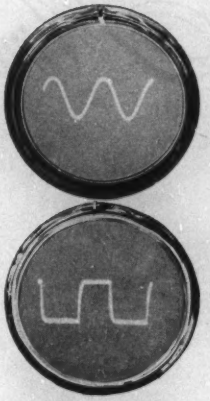
STORAGE TUBES

MEMOTRON

The MEMOTRON, a direct-display cathode ray storage tube, retains traces and transients until intentionally erased. Analysis and comparison are possible without photography because MEMOTRON visually displays successive transient writings. All displays occur at uniform brightness, regardless of writing speeds, so are easily photographed for file records. Applications: viewing transients in shock testing, read-out of solutions from analog computers, curve plotting at high and low speeds, electrocardiography, vectorcardiography and heart sounds.

General Specifications:

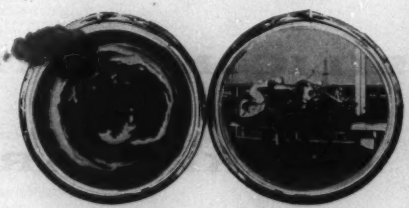
RESOLUTION...50 to 60 written lines per inch.
WRITING SPEED...0 to at least 100,000 inches/second.
BRIGHTNESS...50 foot-lamberts.
USABLE SCREEN DIAMETER...4 inches.
DIMENSIONS...Over-all length: 18 1/2 inches ± 1/2 inch.
Bulb diameter: 5 5/8 inches maximum.
Neck diameter: 2 1/4 inches ± 3/32 inch.



Photos show single transient pulses, 20 microseconds wide with a one microsecond rise time, showing writing capabilities of one million inches per second. These photos were taken in full daylight without a hood.

TONOTRON

The TONOTRON, another exclusive Hughes direct-display cathode ray storage tube with a 5-inch screen, presents a complete spectrum of grey shades. The high light output makes a hood unnecessary, even when viewing in full daylight. TONOTRON's length of persistence and rate of decay are controllable. Superior presentation of the grey scale assures "high fidelity" picture reproduction. Applications: radar, Narrow Band Television, instrumentation, etc.



Photos: Left, weather radar with brilliant halftone picture on TONOTRON. Right, TONOTRON freezes action picture until intentionally erased.

TYPOTRON

The TYPOTRON is the first commercially available storage tube for displaying printed data rapidly. A choice of 63 characters is available for the presentation of data in words, numbers or symbols. As a high-speed digital read-out device, the TYPOTRON writes characters 1/8 inch in size at speeds of at least 25,000 characters per second. The written information remains visible indefinitely without fading or blooming, until intentionally erased. This feature makes TYPOTRON an ideal read-out device in many digital computer applications.

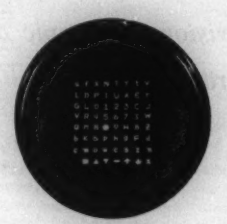


Photo: Presentation of all available characters.

HUGHES PRODUCTS

A DIVISION OF THE HUGHES AIRCRAFT COMPANY

ELECTRON TUBES

Our applications engineers invite your inquiries regarding specific uses of these tubes. For further information and descriptive literature please write to:

HUGHES PRODUCTS · ELECTRON TUBES
International Airport Station
Los Angeles 45, California

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Patent Applied For

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Export: Ad Auriema, Inc., New York City

Industrial Notes

(*Continued from page 22A*)

Electric Airport Fountain. A gleaming, block-long fountain and water display has been drawing increasing attention from travelers and visitors at the Greater Pittsburgh Airport. The six-tiered water display, believed to be the largest electric fountain in the world, consists of the central basis and five stepped reflecting pools. It has 110 jets capable of pushing multi-colored water plumes 75 feet into the air. The reflecting pools are arranged in a series of cascades down which water tumbles before returning underground to the central basin. At night the entire display is illuminated by a series of ground level and underwater floodlights. The giant plumes hurled into the air by the central basin are illuminated in blue while the reflecting pools and cascades are lighted in violet, red, orange, yellow, and green. A specially designed sound system has been built into the fountain to provide soft music for sightseers and passersby. Surrounding the mammoth water display are 12 landscaped gardens. Electrical components for the fountain, including floodlights, motors, and control, were supplied by the General Electric Company which also provided application engineering assistance for the contractor.

The Fixer Mixer. An electronically controlled system for making photographic fixing solution in 5,500-gallon batches, called a fixer mixer, is capable of turning out the first neatly packaged bottle from the 5,500-gallon batch as early as $2^1/_2$ hours after start of the mixing cycle. Fixing solution is used to arrest development of the photographic image and make it permanent. The new equipment, now in use, is built vertically into four stories of the Eastman Kodak Company's powder and solutions building at Kodak Park. Once a starting button is pressed, the fixer mixer is guided by electronic controls through a sequence of reactions ranging from the fourth-floor solution mixing area to a series of pumps, filters, and tank in the basement.

New Plant in Denver. Ground has been broken for a new production facility of The Ramo-Wooldridge Corporation, Los Angeles, Calif. The plant, which will be located near Englewood, south of Denver, Colo., will cover 140,000 square feet and will be used to produce electronic systems. It will also house development and liaison facilities. George Fenimore will be acting manager of the new production facility. The facility will be completed by the middle of 1957.

Square D To Build Plant. An electrical equipment plant will be built by Square D Company on a site in Lexington, Ky. The most modern, high-production machinery will be installed in the facility. An initial

(*Continued on page 32A*)

All Hughes diodes resemble each other—externally. Germanium point-contact or silicon junction, they are all glass-bodied* and tiny (actual dimensions: 0.265 by 0.105 inch). But minute, meticulously controlled variations in the manufacturing process impart individual characteristics to the diodes, make them just right for specific applications. This gives you the opportunity of selecting from a line which includes literally hundreds of diode types.

So, when your circuitry requires varying combinations of such characteristics as... high back resistance... quick recovery... high conductance... or high temperature operation, *specify Hughes.* You will get a diode with mechanical and electrical stability built in. You will get a diode which was manufactured first of all for reliability.

*Nowhere else have glass packaging techniques been developed to a comparable extent, for the Hughes process has many unique aspects. They are difficult to duplicate, yet are instrumental to the manufacture of diode bodies which are completely impervious to contamination and moisture penetration.

HUGHES
SEMICONDUCTORS

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A DIVISION OF THE HUGHES AIRCRAFT COMPANY

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TOTAL FAILURE PROTECTION

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investigate TRANS-O-MATIC AUTOMATIC TRANSFER SWITCHES

Trans-O-Matic's compact, failure-proof design employs two standard circuit breakers, one from the normal and one from the emergency source, either of which will supply the load. Relay-actuated motor operates circuit breakers for positive mechanical transfer with continuous service in normal or emergency position. Available in capacities to 600 volts, 800 amps, interrupting capacities to 50,000 amps RMS. Prompt delivery in most sizes.

OPTIONAL FEATURES

Adjustable time delay on restoration to 20 minutes • Engine starting contact • Test pushbutton • Pilot lights for switch position • Special enclosures

LAKE SHORE Electric CORPORATION
BEDFORD, OHIO

Industrial Notes

(Continued from page 28A)

requirement of several hundred employees is anticipated. Meanwhile, the company is launching pilot operations in the same city and has leased a 12,500-square-foot building for the assembly of special panelboards and switchboards for regional markets.

Animal Protection. Squirrels and birds can safely perch on rural distribution transformers equipped with a line and bushing guard developed by General Electric Company. The 12-inch sleeve of a synthetic, rubber-like material fits over the high voltage cover bushing and primary lead, preventing the squirrel or bird from causing a short circuit from the primary lead to the grounded tank. The bushing guard was developed at the request of several Midwest utilities which had been hit by epidemics of squirrel and bird outages on rural lines. The flexible synthetic material is unusually durable and extends higher up the primary lead than other bushing guards. It is secured by tightening a screw in the metal fitting at the top. It will fit a variety of self-protected transformers with valve-type lightning arresters. The bell-like bottom portion is shaped to cover, but not interfere with, the external gap from bushing to lightning arrester.

Porcelain With a Plus! This new movie, filmed by Line Material (L-M) Company, presents electrical porcelain manufacturing from raw materials to finished products. It shows the step-by-step production and quality control procedures used at Illinois Electric Porcelain Company, Macomb, Ill., in producing electric transmission and distribution porcelain products. Line Material Company distributes to the electric power industry Illinois' standard line of porcelain insulators. A showing of the 16-mm, 28-minute, sound and color film can be arranged by contacting a local L-M representative or by writing Line Material Company, Milwaukee 1, Wis.

NEW PRODUCTS

All-Transistor Pocket Radio. This product, available with rechargeable batteries good for 10,000 hours of use, has been announced by the General Electric Company's radio receiver department. Featured with the recharger carrying case as an accessory are two nickel-cadmium rechargeable cells which fit into the radio in place of standard mercury or carbon pen-light batteries and can be re-energized as many as 200 times, simply by plugging into any a-c house outlet overnight. The radio will operate while recharging, if desired, and will play an average of 50 intermittent hours per charge at medium

(Continued on page 42A)

Photo courtesy Public Service Electric and Gas Company of New Jersey

J-M Transite Ducts go in quickly, easily and permanently

Quick, low-cost installation is promoted by Transite Ducts. The light, 10-foot lengths are easily handled . . . and readily joined with either Transite Couplings or J-M Plastic Couplings. Many fittings are available to simplify even the most complicated installation. The permanently smooth interior surface of these asbestos-cement ducts prevents cable injury, makes long pulls possible and simplifies cable replacement.

Incombustible Transite Ducts confine arc damage, protecting adjacent cables from heat and flame. Inorganic, nonmetallic, Transite Ducts are corrosion-resistant, immune to rust and rot and unaffected by electrolysis. These ducts dissipate heat faster, reducing I^2R losses, enable cables to carry heavier loads and prolong insulation life.

Available in 2 types: Transite Conduit for exposed work and installation underground without concrete encasement; and Transite Korduct for installation in concrete.

Let us send you more information about Transite Ducts.
Just write to Johns-Manville, Box 14, New York 16, N. Y.

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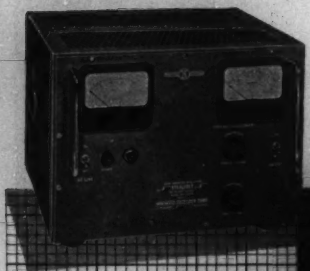
Johns-Manville TRANSITE® DUCTS

TRANSITE KORDUCT®—for installation in concrete

TRANSITE CONDUIT—for exposed work and installation underground without a concrete encasement



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D.C. POWER SUPPLY

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EXCELLENT STATIC and DYNAMIC REGULATION
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NO TUBES, NO MOVING PARTS
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Stablvolt© MR 532-15 D.C. POWER SUPPLY

Exclusive MRC **dual** magnetic, tubeless circuitry efficiently isolates line voltage transients from the d.c. output, giving you precision regulation unobtainable with conventional magnetic amplifier-type voltage regulator systems. Circuit uses high-performance flux oscillators in connection with high-gain magnetic amplifiers, eliminating vacuum tubes, mechanical references and other delicate elements, and providing excellent dynamic and static regulation.

The MR 532-15 is short circuit-proof. When short circuited, line current is automatically limited, protecting power supply from internal damage. Normal operation is resumed automatically—no re-setting of switches, no fuses, no downtime. **Extremely wide voltage range** is accomplished by means of static magnetic circuitry. No transistors—no variable transformers.
A superior performer for industrial, laboratory and original equipment applications. Competitively priced.

Model MR 532-15/SPECIFICATIONS

Type: Dual magnetic regulated
Input: Voltage Range 80-150V; Frequency Range 57-63 cps
Output: Voltage Range 5-32V DC; Extended Range 3-36V DC; Current Range 0-15A DC; Short Circuit Current 30A DC
Voltage Adjustment: Continuous with vernier.
Ripple: less than 50 millivolts entire voltage range
Response time: less than 25 milliseconds for line transients; max. 150 milliseconds for load transients

Size: 17.5" w x 12.5" h x 15.5" d (also avail. for 19" sl'd rack mt.)
Weight: 150 #

REGULATION

Static:	Dynamic:
±¼% for 80-150V line change	less than 1% for 10% line transient
±½% for 0-15A load, 5-32V range	less than 1.5V for 10% load transient
±1% for extended voltage range	

MRC magnetic research corp.
200 CENTER STREET, EL SEGUNDO, CALIFORNIA,
Phone: ORegon 8-8921

New Products

(*Continued from page 32A*)

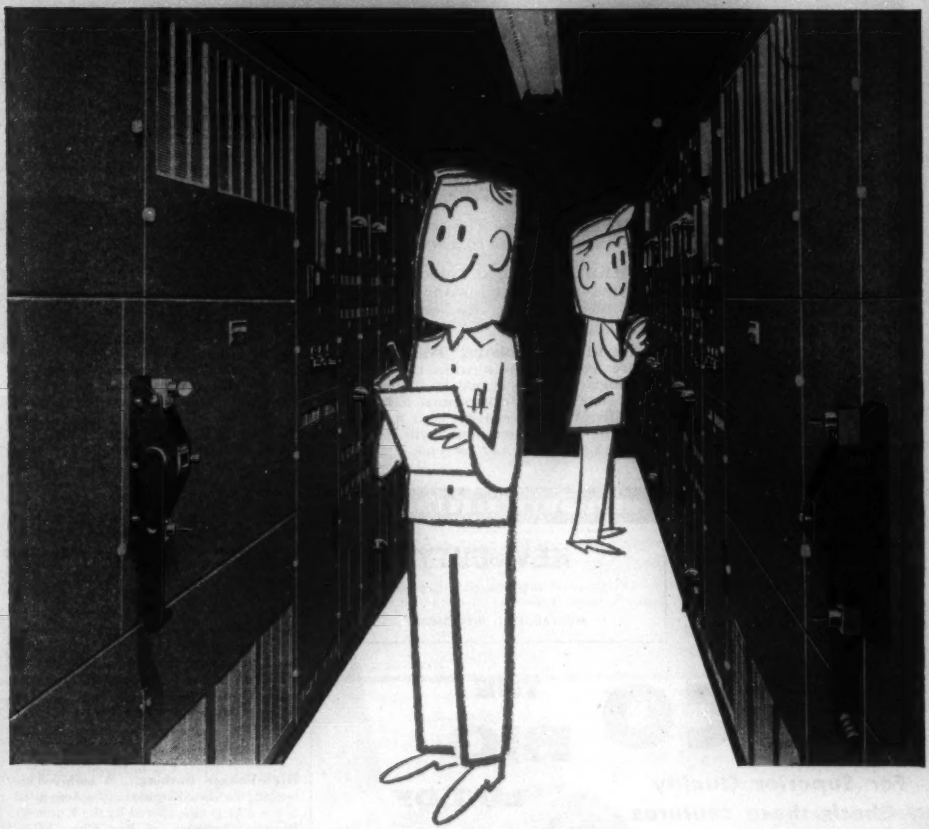
volume level for a total of 10,000 hours. Only 6¼ inches long, 3⅓ inches high, and 1⅜ inches thin, and weighing only 20 ounces including batteries, the 6-transistor radio has improved circuitry and antenna design which provide twice the sound volume and four times the sensitivity of previous transistor models. An earphone may be plugged into the back of the set for private listening. Models *P-715* and *P-716* both have lightweight, unbreakable cabinets of extruded anodized gold aluminum.

Batteries. A line of Exide-Manchex batteries which feature longer life and higher instantaneous discharge rates has been introduced by Exide Industrial Division, The Electric Storage Battery Company, Philadelphia, Pa. The batteries, in heat-resistant polystyrene jars, are designed for stationary power applications in utility, telephone, railway, and industrial plant operations. Additional major improvements provide reduced maintenance because of less frequent additions of water; more effective sealing, easier cleaning; and ready adaptability to cycle as well as float service. An exclusive feature of this battery is the Planté positive plate consisting of a cast lead antimony grid into which rosettes or buttons of pure lead are permanently locked and then coated electrochemically with the active material (lead peroxide). The battery has an unusually long life because the active material cannot wash out and the buttons give a constant supply of solid lead for conversion into active material. For further information on this Manchex battery, write Dept. M, Exide Industrial Division, The Electric Storage Battery Company, Box 8109, Philadelphia 1, Pa.

Splicing Kits Available. A series of three new splicing kits for casting in-line cable splices in epoxy resin have been added to its line of in-the-field splicing kits by the Minnesota Mining and Manufacturing Company, Department D6-152, St. Paul, Minn. Using the kits, water-tight splices can be insulated in the field in less than ten minutes. Once a splice has been cast, it is permanently encased in a block of insulating resin which will remain solid despite aging, heat, and pressure. Design of the kits makes it possible to use them underground or when splices are exposed to severe weather and moisture conditions. Each kit contains all materials necessary for encapsulating a cable splice.

Tubeless Regulated D-C Source for Unattended Installations. An improved tubeless regulated d-c source, model *MA-65A*, is a low voltage, high current supply, utilizing magnetic amplifier circuitry for greater reliability. This source is recommended for unattended installations, because of its maintenance-free performance.

(*Continued on page 48A*)



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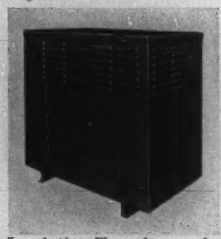
I-T-E Secondary Unit Substations make electric power more dependable, more economical. They bring higher voltages nearer the load, reduce power losses. They increase machine efficiency, reduce voltage drops inherent in long low-voltage runs. They save space—all necessary components are housed in one functionally designed unit. They protect plant personnel—all live parts are isolated and metal enclosed.

In addition, you save in delivery and installation time. All I-T-E Secondary Unit Substations are assembled, tested and shipped ready to install from one source of supply. And they are available for any application, indoor or outdoor, in any standard rating.

For complete information, contact your nearest I-T-E sales office. Or write I-T-E Circuit Breaker Company, 19th & Hamilton Sts., Philadelphia 30, Pa.

I-T-E CIRCUIT BREAKER COMPANY
Switchgear Division

Single-Phase Transformer, with circuit breaker*, for power and lighting loads. Sizes from 5 to 1000 KVA. *Optional



Insulating Transformer for three-phase operation, 480 volt primary; 120/208 volt secondary, 60 cycles. Sizes from 6 to 2000 KVA.

HEVI-DUTY SINGLE AND THREE-PHASE INSULATING TRANSFORMERS ARE...

COOL — Have highly efficient chimney-type ventilation system.

QUIET — Special core and coil design greatly reduces transformer hum.

CONVENIENT — Top cover is removable for easy access to leads.

DURABLE — Rigidly blocked coils are vacuum-impregnated with special varnish to insure long trouble-free operation.

Hevi-Duty Insulating Transformers are available in a wide variety of standard models or may be engineered to your exact specifications. Send for Bulletin 499 or outline your requirements and our engineers will recommend a transformer for you.

HEVI-DUTY ELECTRIC CO.

HEVI-DUTY

HEAT-TREATING FURNACES, ELECTRIC EXCLUSIVELY
DRY TYPE TRANSFORMERS — CONSTANT CURRENT REGULATORS

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For Superior Quality
√ Check these features

- ☐ Pure copper, 100% conductivity
- ☐ Wide wire range—re-usable
- ☐ U/L-CSA Approved
- ☐ Compact—rugged
- ☐ Advanced designing
- ☐ Sound engineering
- ☐ Speedy installation
- ☐ Cool operation—takes overload
- ☐ No special tools needed
- ☐ All screws wax-treated for better clamping

ALL THESE FEATURES AT LOW COST

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Write for Catalog #50 and Samples

ILSCO CORPORATION

5743 MARIEMONT AVE. CINCINNATI 27, OHIO

New Products

(*Continued from page 42A*)

Input range of the model *MA65A* is 105–125 volts a-c, 1 phase, 60 cycles. Output voltage is 5.4 to 6.6 volts d-c, adjustable. Load range is 0 to 5 amperes, ripple is 1 per cent maximum. Regulation accuracy is ±0.2 per cent against line or load (1/10 to full). Recovery time is 0.15 second. Model *MA65A* is supplied for rack mounting, with a cabinet available for bench use. Complete specifications and performance data are available from Sorensen and Company, Inc., Fairfield Avenue, Stamford, Conn.

Three-Way Light Bulb. Development of a new 3-way light bulb for portable lamps which produces three new "speeds" of light, and is geared to meet the exacting demands of television viewing has been announced by General Electric Lamp Division, Nela Park, Cleveland 12, Ohio. The new "high-low" is actually three light bulbs in one: a 30-watt, a 200-watt, and a 230-watt. The 30-watt low level provides an excellent lighting situation for television viewing. It also serves as a practical night light. The 230- and 200-watt levels of light make for more comfortable reading, studying, or sewing. The new "high-low" is intended for use in portable floor and table lamps having 3-way switches. By a single turn of the switch, lighting levels can be changed from a new low to an eye-guarding high without need for going through an intermediate stage. A second turn of the switch brings both the 30-watt and 200-watt filaments into use for a maximum light output of 230 watts.

High-Voltage Bushing. A high-voltage bushing for distribution transformers rated above 5 kv is now offered by the Kuhlman Electric Company of Bay City, Mich. The new bushing features a hard rubber hand-grip insulated connector for protection against service interruptions caused by birds and/or animals coming in contact with live parts. Based on the principal of Kuhlman's original "Quick-Grip" design for voltages below 5 kv, the hand-grip connector also allows quick easy line installation. Secure high voltage connections are made by simply turning the hand grip. No tools are necessary.

High Temperature Potentiometer. The development of a high temperature precision potentiometer rated to 200 C, has been announced by the Electromechanical Division of G. M. Giannini and Company, Inc., 918 East Green Street, Pasadena 1, Calif. The new potentiometer, model *875T*, is a servo-mount subminiature single turn rotary precision unit with a power rating of 2 watts at 150 C. Despite its small 7/8-inch diameter, linearity is ±0.5 per cent or better, and resolution is as high as 0.06 per cent. Precious metals are utilized in the coil and wiper to permit

(*Continued on page 52A*)

Natvar

Natvar Products

- Varnished cambric—cloth and tape
- Varnished canvas and duck
- Varnished silk and special rayon
- Varnished—Silicone coated Fiberglas
- Varnished papers—rope and kraft
- Slot cell combinations, Aboglas®
- Isoglas® sheet, tape, tubing and sleeving
- Vinyl coated—varnished—lacquered tubing and sleeving
- Extruded vinyl tubing and tape
- Styroflex® flexible polystyrene tape
- Extruded identification markers

Ask for Catalog No. 23

Utilities today are doing an outstanding job of keeping up with the relentlessly increasing demand. In the race to serve wider areas, and areas of doubled density, distribution transformers have had to handle loads far in excess of rated capacity for long periods without interruption of service.

Principal manufacturers of distribution transformers rely upon Natvar 500 Extruded Vinyl Tubing to insulate and protect high voltage leads. It is resistant to heat and oil, and does not impair the properties of transformer oil. Natvar 500 was formulated expressly as high voltage lead insulation in oil filled transformers. It is manufactured in sizes and wall thicknesses dictated for this service.

Natvar 500 and other Natvar flexible electrical insulating materials are available for immediate delivery, either from wholesalers stocks or direct from our own. Full data on request.

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COMPONENTS FOR COMMUNICATION SYSTEMS

Radio Engineering Products produces a wide range of standard components for use in communication systems. In most cases these components can be delivered from stock.
FILTERS: Filters of advanced design are available for carrier telegraph, carrier telephone, and telemetering systems. These include channel filters, low-pass filters, and line filters.
JACKS and MOUNTINGS: Two standard 1¾" by 19" jack mountings are available. Type F6097A mounts 52 single jacks, and type F6097B 26 single jacks. Type F8410 jack is a double jack with parallel break contacts, interchangeable with type 410A.
REPEATING and RETARDATION COILS: A large number of standard types are carried in stock. These include voice-frequency and carrier-frequency line coils, hybrid coils, and retard coils for telephone and telegraph applications.

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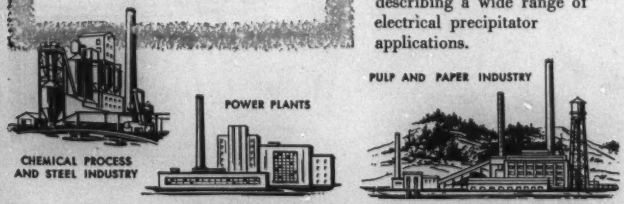
To maintain visually clean stacks at all times, industry is turning to the long experience of Research-Cottrell in the design and manufacture of highly efficient Cottrell Electrical Precipitators. We've spent 40 years in solving such problems as nuisance abatement, cleaning gas for subsequent use and recovering materials of value. Write for illustrated bulletin describing a wide range of electrical precipitator applications.



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New Products

(*Continued from page 48A*)

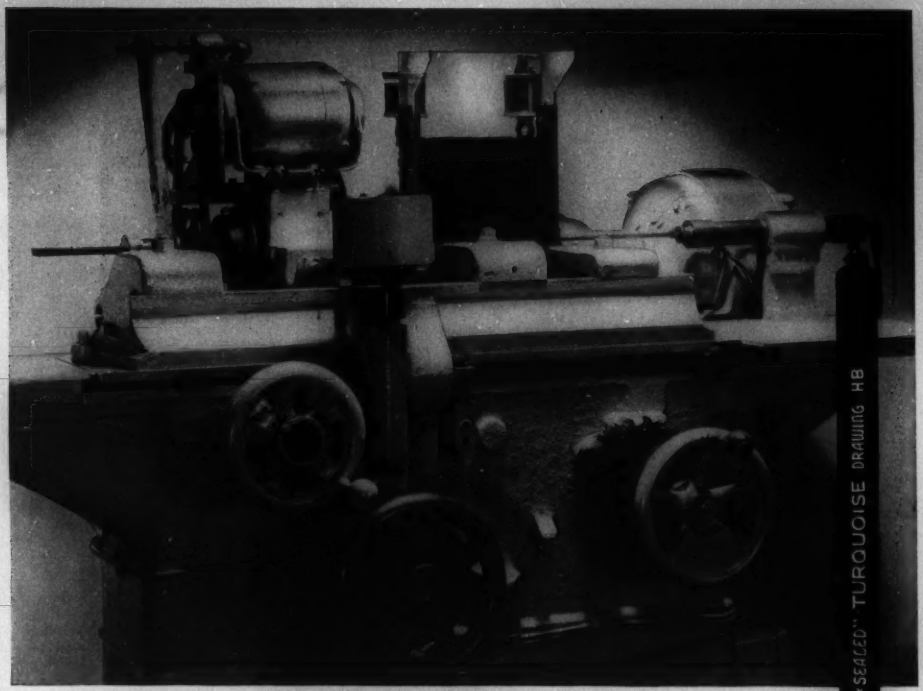
low contact pressure and to provide long, noise-free life. Potentiometer coils can be supplied with taps, and as many as six sections can be ganged on a common shaft. Recommended for applications requiring high power at elevated temperatures, the Model *875T* high temperature potentiometer has a precision ground stainless steel shaft mounted in ball bearings, and is encased in a machined, anodized aluminum housing.

Tools That Aid Standardization. Two versatile hand tools for installing a complete range of overhead distribution line connections have been developed by Burndy Engineering Company, Inc., Norwalk, Conn. It is said that one tool or the other will equip a crew to install all of its secondary line or service drop connections. Offered as aids to equipment standardization by electric utilities, the new tools are designated as the *MD4* and *MD5* Hytools. The *MD4* uses inexpensive, interchangeable die inserts to make connections ranging from a No. 8 service tap through a full-tension 2/0 splice on copper, aluminum, or aluminum cable steel reinforced (ACSR) with a single tool. A special cam and lever action develops the crimping forces up to 9,000 pounds required to install connectors on this wide range of conductors. The *MD5*, weighing only 4¾ pounds, is a compact, economic tool that can install splicing and tapping connectors on conductors through 2/0 ACSR. A toggle action enables the tool to deliver up to 6,500 pounds crimping force.

Desk Racks. The Modu-Rak line of miniature desk racks designed for modular construction of test equipment makes possible any number of separate units in one rack. It makes any part of the electronic system easily accessible for assembly or repair. Technicians need simply to pull out and service the particular circuit they are interested in without disturbing the rest of the equipment. The flexibility of these Modu-Raks saves countless hours of design and assembly time and greatly cuts costs as well. Premier's Modu-Raks are designed for standard 19-inch, 9½-inch and 4¾-inch rack panels. They are sturdily constructed of 16-gauge cold rolled steel and are attractively finished in gray hammertone with rounded front corners and red striped chrome trim top and bottom. A complete selection of vertical strips, angle brackets, horizontal dividers, and panels are available for subdividing Modu-Rak into modular units. Send for catalogue sheet from the Premier Metal Products Company, 337 Manida Street, New York 59, N. Y.

Tiny Fire Alarm. This fire alarm is installed by plugging it into any standard a-c outlet and it shrieks an ear splitting alarm at the first sign of fire or ominous overheating. Intended for plants, offices, stores, warehouses, and homes, it can be easily and inexpensively planted wherever history or

(*Continued on page 66A*)



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sharpens pencils to one ten-thousandth of an inch!

To perfect this gentle giant, Eagle laboratory technicians spent three years and $25,000—because Two-Ton Tillie makes our other pencil tests make sense.

It sharpens *all* test leads, thick or thin, hard or soft, Eagle or competitive, down to a cylindrical point of .050" diameter (± .0001") as illustrated at right. You can see that such a "point" will present a constant area to the paper throughout any test and will let us compare smoothness, durability or opacity on a fair and equal basis.

It will also sharpen at any desired angle, creating identical long-tapered drafting points for needle-point strength tests.

The results enable us to test our research, confirm our improvements and maintain our quality. Whether *you* sharpen your pencil by knife, razor, sandpaper block, or regular pencil sharpener, remember Two-Ton Tillie. It's part of Eagle's continuing research to *keep* TURQUOISE the finest drawing pencil in the world.

SAMPLE OFFER: *Send for a free Turquoise Drawing Pencil in the grade you prefer, 6B to 9H. Prove it's best in your own hand. (Please mention this magazine.)*

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TURQUOISE®

DRAWING PENCILS AND LEADS

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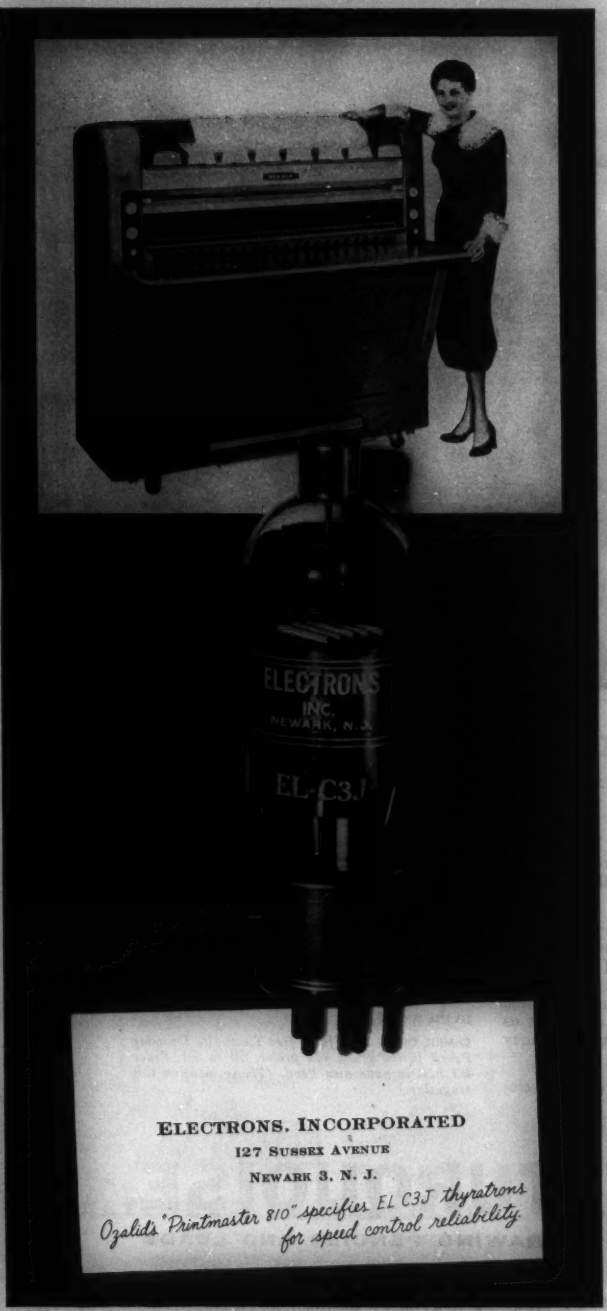
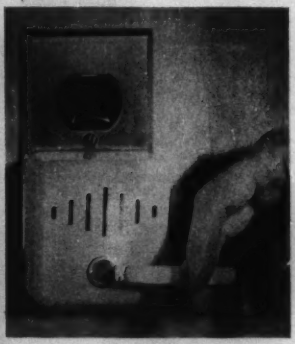


New Products

(*Continued from page 52A*)

hunch indicate fire may gain costly headway before being detected. This portable, reusable alarm draws no current except when signaling and is an excellent substitute for, or companion system to, sprinkler and other standard fire detection and fire fighting systems. To insure adequate time



for fight or flight, its sensitive thermostat triggers the alarm when heat reaches 140 F, and continues it until conditions return to normal, about 100 F. It can be reassuringly tested from time to time by holding a lighted cigarette or match to the circular thermostat button on its face. For further information contact Laramie Chemical Corporation, 290 Main Street, Stamford, Conn.

Xerography for Slides. Transparencies for lantern slides and overhead projectors may now be made by xerography. The latest dimension in an already versatile copying process offers striking time and cost savings to visual education and communications groups. Government, industry, and schools are expected to benefit. Lecturers using overhead projectors will find the development especially helpful. The steps required in the xerographic production of transparencies closely parallel those used in standard xerographic copying work. There are two principal differences, however. One is that the copy is made onto a sheet of film or acetate instead of onto paper or an offset paper master. The other is that the fusing of the powder image to the acetate is done by vapor rather than heat. For further information write M. E. Harris, The Haloid Company, Rochester 3, N. Y.

Lighting Layout Kit. This kit has been developed by General Electric's large lamp department for use by the lighting industry and planned for the use of electrical contractors, distributor salesmen and lighting men, as well as utility lighting men. It makes possible the quick calculation of the

(*Continued on page 70A*)

now OHMITE® offers the ONLY complete line of RESISTORS to meet MIL-R-26C characteristics

Y HIGH TEMPERATURE 350C CHARACTERISTIC
HIGH INSULATION RESISTANCE

V HIGH TEMPERATURE 350C CHARACTERISTIC

AND **G**

TAB-TERMINAL TYPE Characteristics V and G

Style	Over-all Length	Diameter	*Watts	††Watts
RW-29	1¾"	½"	8	11
RW-30	1"	19/32"	8	11
RW-31	1½"	19/32"	10	14
RW-32	2"	19/32"	12	17
RW-33	3"	19/32"	18	26
RW-35	4"	29/32"	38	55
RW-36	4"	1-5/16"	54	78
RW-37	6"	1-5/16"	78	113
RW-38	8"	1-5/16"	110	159
RW-47	10½"	1-5/16"	145	210

TAB-TERMINAL TYPE Characteristic Y

Style	Over-all Length	Diameter	†Watts
RW-30	1"	19/32"	11
RW-33	3"	19/32"	26
RW-37	6"	1-5/16"	113
RW-47	10½"	1-5/16"	210

FLAT TAB-TERMINAL TYPE (Stack Mounting) Characteristics V and G

Style	Over-all Length	Width and Thickness of Core	*Watts	††Watts
RW-20	2½"		15	21
RW-21	3¼"	1-3/16"	22	31
RW-22	4¾"	x	37	53
RW-23	6"	¼"	47	68
RW-24	7¼"		63	91

AXIAL-TERMINAL TYPE Characteristics V and G

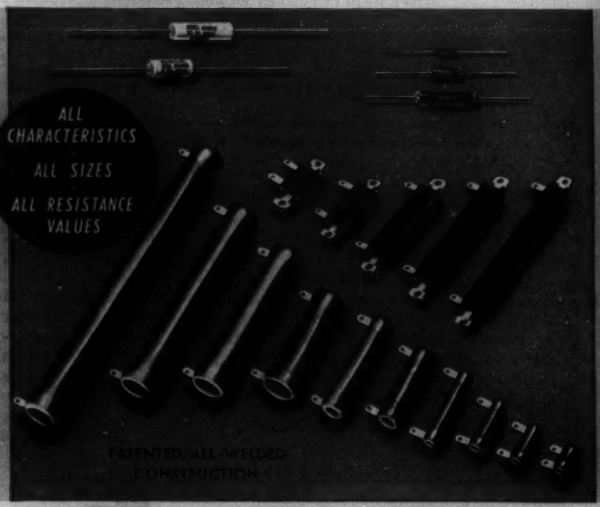
Style	Length of Core**	Diameter	*Watts	††Watts
RW-55	1⅜"	15/32"	5	7
RW-56	2"	15/32"	10	14
RW-57	1"	5/16"	5	6.5
RW-58	1¾"	11/32"	8	11
RW-59	½"	3/16"	2.5	3

**Watts free air MIL Characteristic "G."
†Watts free air MIL Characteristic "Y."
††Watts free air MIL Characteristic "V."

**1-½" wire leads.

Even including resistors wound with the finest wire size (.00175)

The Ohmite resistor types shown in the table above can withstand a continuous operating temperature of 350C—the high temperature requirement of MIL-R-26C, Char. "V." These resistors also meet Characteristic "G." The new Char. "Y" combines all requirements of Char. "V" and "G" plus extremely high insulation resistance at the end of the moisture-resistance test. Under all three Char., "V," "Y," and "G," Ohmite resistors have to satisfy severe moisture-resistance tests, thermal shock tests, vibration tests, and many others. The Ohmite line of wire-wound resistors is the most extensive available in the industry.

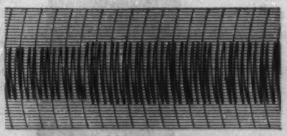


Be Right with OHMITE®

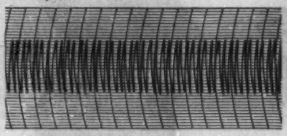
RHEOSTATS
RESISTORS
RELAYS
TAP SWITCHES
TANTALUM CAPACITORS

OHMITE MANUFACTURING COMPANY, 3614 Howard Street, Skokie, Illinois

Regulation in *less than* 1/50th cycle . . .



Output of typical electromechanical regulator in response to step change in input voltage. Average correction rate of 6v. per sec.



Output of Curtiss-Wright Distortion Eliminating Voltage Regulator from same input. Full recovery in 330 microsec.

Simultaneous two-pen recording of 60 c.p.s. voltage

PLUS Pure Sine Wave Power

CURTISS-WRIGHT LINE REGULATOR

- **Electronically regulates r.m.s. and peak voltage simultaneously to ±1%.**
- **Reduces typical power line distortion to less than 0.3%.**
- **Furnishes 1.4 KVA of distortion-free power.**
- **Introduces no phase shift between input and output.**
- **Simultaneously provides additional 4 KVA of ±1% electromechanically regulated power.**

Faster recovery time (less than 1/60th cycle, or 330 microseconds) plus the unique ability to *eliminate* line distortion — these are the reasons why the Curtiss-Wright Distortion Eliminating Voltage Regulator has been chosen by more and more laboratories and production test departments. Besides general laboratory use, this line regulator provides simpler, more accurate calibration of meters . . . better design of transformers, synchros, motors . . . easier testing of such components, with fewer rejects . . . easier, more accurate measurement of magnetic properties and receiver sensitivity . . . better a.c. computer performance . . . elimination of fast line transient effects. Write for details.

Electronic Component & Instrument Sales Department

ELECTRONICS DIVISION
CURTISS-WRIGHT
CORPORATION • CARLSTADT, N. J.

(*Continued from page 66A*)

number of fixtures, rearrangement of the lighting plan, and a final paste down of the plan. It has been designed to help provide proper lighting for a small store, office, or factory. This kit includes 12 sheets of graph paper to provide a scaled floor plan, an envelope of cardboard fixture units, an envelope of pressure-sensitive fixture units

for the final layout, a pamphlet on fluorescent lamps and auxiliary equipment, a pamphlet on essential data for general lighting design, and a fluorescent lighting estimator which aids in establishing the number of fixtures needed to maintain the predetermined footcandle level. The kit is available through Department WE-7, General Electric Company, Large Lamp Department, Nela Park, Cleveland 12, Ohio. The price is $1.75.

TRADE LITERATURE

Free Drafting Booklet. A 56-page booklet on standard and simplified drafting practices has been made available. The first section of this 8 1/2 by 11-inch publication contains a speech on this provocative subject as given by J. H. Bergen, American Machine and Foundry (AMF) Standards Administrator, before the American Society for Engineering Education. The remaining 44 pages are devoted to the details of AMF standard on drafting room practice and simplified drafting. Those interested in obtaining a free copy of the new 56-page booklet may write on company letterhead to: Public Relations Department, American Machine and Foundry Company, 261 Madison Avenue, New York 16, N. Y.

Silver Plating and Nickel Undercoating. An eight page technical paper has been prepared describing the "Silvrex" bright silver plating process. It covers in detail such vital topics as bath make-up and maintenance; anodes, tanks, temperature; current densities; agitation; plating procedure; and simplified removal of solution

(*Continued on page 80A*)